# STORIES OF INDUSTRY

EDUCATIONAL PUBLISHING CO.

# STORIES
## OF
# INDUSTRY

VOLUME I

BY

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REVISED EDITION



EDUCATIONAL PUBLISHING COMPANY
BOSTON
NEW YORK CHICAGO SAN FRANCISCO

# PREFACE

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Southey tells us that "it is with words as with sunbeams, the more they are condensed the deeper they burn."

Having this thought in mind, therefore, we have endeavored to give, in as few words as possible, a little interesting information for young people; something that will aid them in acquiring habits of *observation* and lead to a knowledge of the *common things* connected with the arts on which depends the well-being of our race.

Truly "that is a good book which is opened with expectation and closed with profit;" if this may be said, even in a small degree, of this little volume, the authors will feel more than compensated for the labor and thought expended in its preparation.

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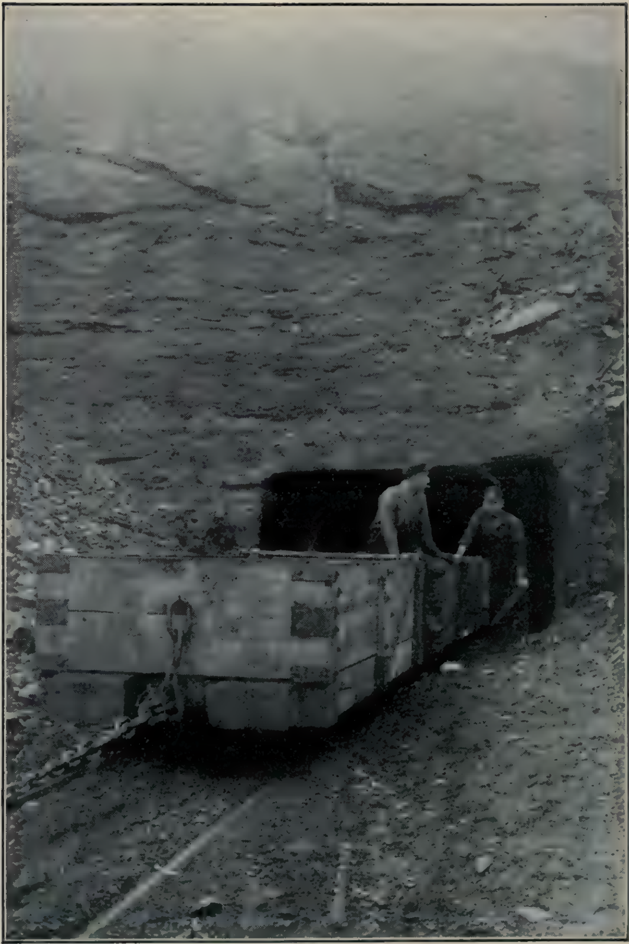


ANTHRACITE MINES, SCRANTON, PA.—EMPTY COAL CARS RETURNING TO BE FILLED
(Copyright by Underwood & Underwood, New York)

LOADING COAL AT THE PIT-HEAD.

# STORIES OF INDUSTRY

## COAL

DID you ever stop to think when you have visited some noisy mill or foundry, what a vast amount of coal it must take to turn so much machinery?

Coal is to our manufactories what the main-spring is to the watch, and hardly any labor can be performed without it. Yet, before we can have so much as a hod of coal, mines have to be mapped out by skilful men;

tunnels made or deep shafts sunk; gear fixed to bring the coal up; means tried to drain and air the pits; miners paid for their hard toil and risk of life, and trucks and wagons made to carry the coal. Then there must be roads made to reach the sea-ports; ships to carry the coal over the water, and railways to take it from place to place over the land.

Every step of this work is costly. The sinking of a shaft or pit is very expensive labor, and some pits have been bored very deep without coming to coal. Often after it has been carried hundreds of miles, the coal has to be taken out of the coal ships (colliers), put into barges or lighters to go up the rivers; or, perhaps, is transported to some railway again.

There are several kinds of coal. The varieties generally marketed in the United States are lignite, bituminous, cannel and anthracite.

*Lignite* is a species of soft, reddish, imperfectly formed coal; an intermediate between peat and true coal. It is found in Colorado, the Dakotas, Montana, Wyoming and Oklahoma. It has not yet been successfully used for manufacturing purposes, but in many states west of the Mississippi is in demand for domestic purposes for heating and cooking.

*Bituminous* coal is much softer than anthracite; and, in the market, is generally known as soft coal or steam coal. It contains more oil and vegetable matter than carbon, and has not been submitted to so much pressure in the earth as anthracite coal. It burns with a bright flame, but gives off dense, black smoke. It is much more generally distributed than anthracite, and forms much of the coal mined in Europe.

*Cannel* coal seems to be a formation between bituminous and anthracite; harder than the former, but not as hard as the latter. It is quite scarce, so of not much commercial importance. It is chiefly in demand for burning in open grates.

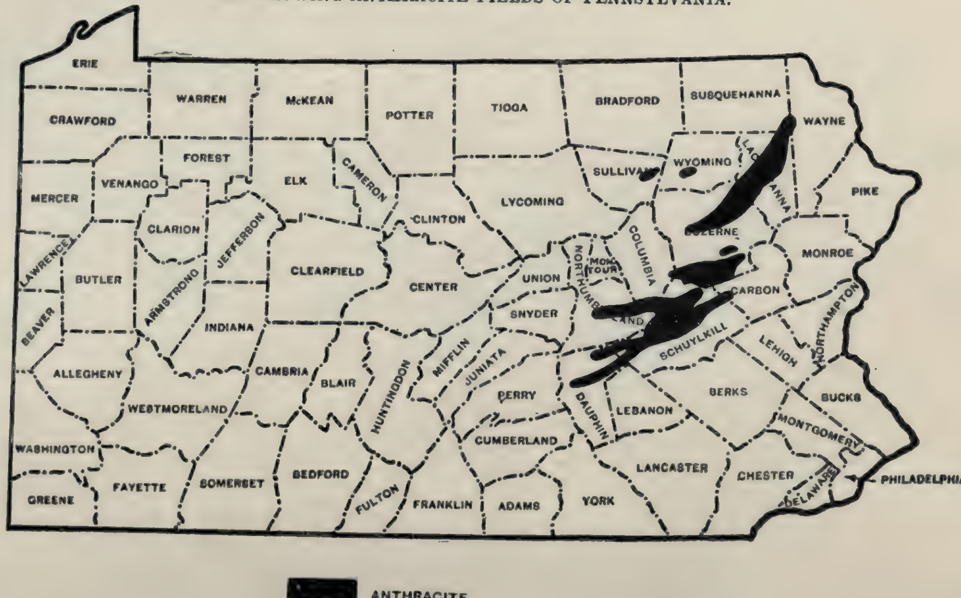
*Anthracite* is the hard, bright coal, chiefly found in eastern Pennsylvania. It is almost pure carbon and burns with little flame or smoke, but gives off intense heat — hence its great demand for domestic purposes.

Until closed stoves and the hot blast for furnaces came into use, anthracite was but little used for fuel, as it does not light easily and requires a strong draught to keep it burning. In fact, it is only a few hundred years since the motive power of steam was called forth by coal. Now nearly every country is scored with steam railways; and our mills and factories are crowded with steam engines and looms.

Before coal was used to produce steam the sites for busy towns were selected near some mill stream; and the woods were seats for smelting iron. Now iron-making has gone to the coal-fields, where the coal, the iron ore, and the lime-stone, or flux, which helps to melt the iron, are all found close together.

The first coal discovered in America was by Father Hennepin, the Mississippi explorer, near what is now Ottawa, in Illinois. In the year 1813 the first mining

MAP SHOWING ANTHRACITE FIELDS OF PENNSYLVANIA.



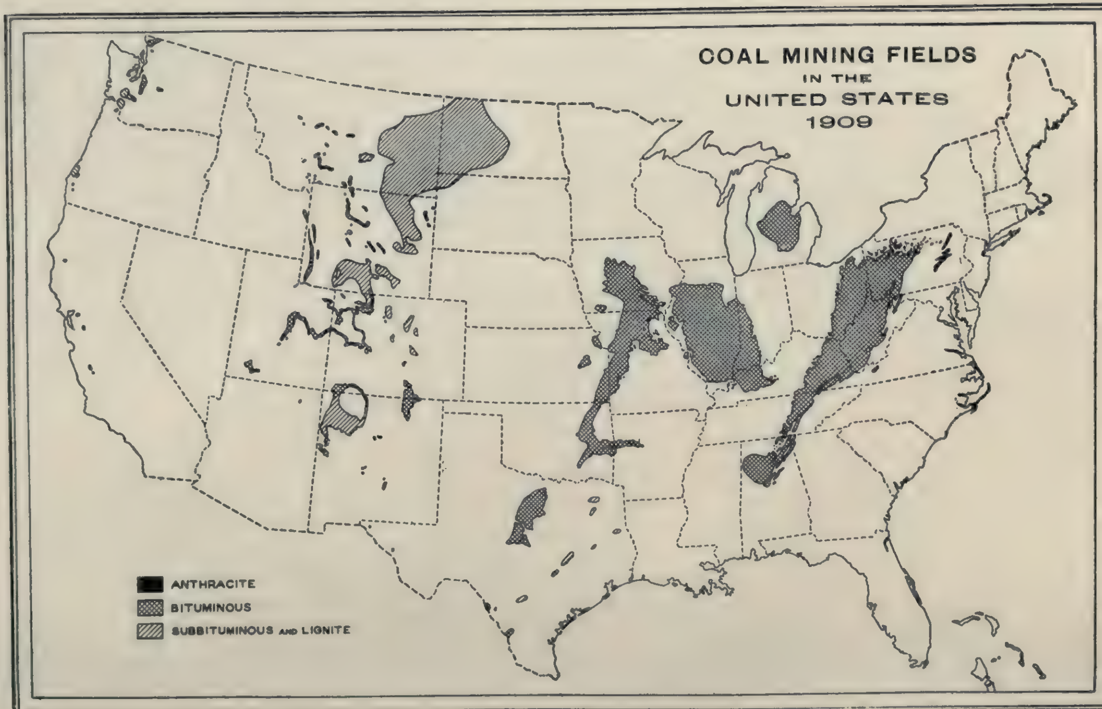
in America was begun, when five boat-loads of coal were floated down the Lehigh River, and sold for twenty-one dollars per ton in Philadelphia.

Regular shipments from the Pennsylvania mines began in 1820, and the industry has steadily grown until the amount carried over the different railroads connecting with the coal region has reached nearly 220,000,000 tons a year.

In 1841, the first furnace of the Lackawanna Iron and Coal Company of Scranton, Pennsylvania, was filled and fired, and though this effort to manufacture iron from local ores proved a total failure, it nevertheless gave a decided impetus to the coal-mining industry. Subsequently iron ore and limestone were brought from a distance, and anthracite was successfully used for smelting iron.

Dr. B. H. Throop reported to an industrial convention at Tunkhannock, Pennsylvania, in the year 1842, that the Lackawanna Valley from Archbald to Pittston "contains upward of one hundred coal mines opened, and many of them are made at present a source of profit both from domestic and foreign markets. There are sent some five or six thousand tons of coal annually by sledges and wagons to the States of New York and New Jersey, in exchange for salt, plaster, etc." Since this beginning the coal industry of Pennsylvania has continuously flourished until the present.

Coal is used in such great quantities, that some people have thought the supply might give out. But


COAL MINING FIELDS
IN THE
UNITED STATES
1909
ANTHRACITE
BITUMINOUS
SUBBITUMINOUS AND LIGNITE

there is very little danger of this. In the first place, think of the coal area of our own land!

There are the great coal-fields bordering the Appalachian Mountains, reaching from the north line of Pennsylvania to the middle of Alabama, 58,737 square miles; the Illinois coal-field, which covers a large part of Illinois and portions of Indiana and Kentucky, its area 64,887 square miles; the Missouri coal-field, lying west of the Mississippi, in the State of Iowa, Kansas, Arkansas, Missouri, and Texas, supposed to extend over 47,138 square miles. Added to this are the anthracite basins of Pennsylvania and Rhode Island, and the coal-fields of Virginia, Michigan, and North Carolina. The map on the opposite page shows the general localities from which anthracite, bituminous, and lignite coals were mined in 1909.

Anthracite is produced almost exclusively in a comparatively small area in eastern Pennsylvania. The most important bituminous field is the Appalachian, extending from western Pennsylvania and eastern Ohio southwestward as far as Alabama; the next most important is that embracing a large part of Illinois, and southwestern Indiana. The large areas shown in North Dakota and the Rocky Mountain states are mainly of lignite and subbituminous coal. New deposits, however, are being discovered every year, and the annual output of 380,000,000 tons of bituminous coal can be maintained for hundreds of years without exhausting the supply.


RELATIVE PRODUCTION OF BITUMINOUS COAL BY STATES — 1909

A MINE CAR LOADED WITH COAL.

# WHAT IS COAL?

WHAT is coal? How came we to know that if we bored pits a quarter of a mile deep, and sometimes deeper, into the earth, we should find a black stone that would burn and be so useful for fuel? Coal is found in seams or beds. In some coal-fields, as many as eighty of these beds have been counted, and in some other places double this number. Some of the seams are only a few inches thick, and they range through every thickness, from two inches to nearly thirty feet. The beds are not dug out for fuel unless they reach a thickness of two or three feet at least, as they would not pay for working. The seams or beds are called measures, and if they had lain flat in the crust of the earth, it is pretty certain that we should never have known much about them. But the coal measures are not flat; they slope or dip, and stretch upward as well as downward, and the edge of the coal bed, here and there, crops out on the surface. This surface coal is not as good as the deep-seated coal, but it was the first used, and it shows the direction of the slope or dip.

Everywhere between the beds of coal are strata or layers of other rocks. These rocks are all of sedimentary origin and consist chiefly of shale, sandstone, clay, limestone, coal, and deposits of sand and gravel. With the exception of the coal, most if not all of the materials of which these rocks are composed were transported and deposited by water and many of them were laid down in an ocean. The various beds were thus deposited in successive layers, one above another, and were spread out over large areas, some of them having an extent of thousands of square miles.

The composition and thickness of each layer varies greatly from point to point because of differences in local conditions under which it was laid down. In places the currents were strong; and the sand and mud brought down by streams was washed and assorted, the light, fine mud being borne away to settle to the bottom in areas where the water was comparatively still, the remaining sand being spread out only so far as the currents were strong enough to carry it. From time to time there were developed local conditions favorable for the growth of lime-secreting animals and plants, which, when they had died, left shells and other remains that in time accumulated in such quantities as to form beds of limestone. Thus, there were deposited various kinds of sediments which were afterward consolidated by pressure into rocks. The sand became sandstone; the fine mud became shale (or clay); and the remains of animals, and perhaps of certain plants, became limestone. Coal was formed from accumulations of plant remains in swamps and lagoons, and fire clay probably from the old soil in which the plants grew. Under such conditions, it should be expected that the beds would grade into one another. This is in fact true, though there are certain beds that are uniformly persistent over comparatively large areas and represent stages of deposition in which thousands of square miles of the sea bottom was covered by material of practically the same kind.

The total thickness of the sedimentary rocks, including both the exposed rocks and those which lie beneath the surface, varies greatly in different parts of the United States. Some are several thousand feet thick, so deep in fact that no drill has ever penetrated to the old granite floor below.

For convenience of description, geologists have separated this column of rocks into several groups according to their age, and have designated these groups, and important beds contained in them, by names.

To account for these great depths and the number of the coal-beds, we may be certain that every seam was, however far back, a field of vegetation on the surface of the earth, and that every layer of shale or clay, now the floor and roof of the coal-beds, was formed by mud settling down at the bottom of water. So we see that the land has been covered by water as many times, at least, as there are strata or layers of shale; and has become dry again as many times as there are beds of coal. We believe, too, because the plants were tropical and of great size, that the coal countries must have been, at times, much hotter than now.

Fossil remains of animals such as can live only in hot climates, and others which can live in cold climates, are found in abundance in the rocks. The nature of the rocks thus prove that at long intervals the land has had to bear the extremes of heat or cold for ages together.

So you see the kind of coal in a bed depends upon the kind of plant or trees that grew upon it when it was at the surface of the earth; upon the amount of pressure above it; and upon heat and time. The giant trees, whose roots and stems are in the coal measures, also show us that the vegetation of the earth, long before man came to live upon it, was in structure something like a moss which now seldom grows more than a foot high.

# VISIT TO A COAL MINE

A mine of coal is dug out on a very regular plan. When a shaft or pit is sunk down to the bed, the miners do not try at once to get all the coal within their reach, but they cut or drive tunnels, which they call drifts, and as soon as they get a little way in, they cut across drifts right and left, so that at last the mine consists of narrow lanes or passages, and huge square blocks or pillars of coal are left to support the roof. As soon as the drifts reach the bounds of the mine, the miners remove these pillars, the most distant ones first, and let the mine fall in; and this is the most dangerous part of their work.

When the mines fall in, it often causes the surface of the earth to sink. In the coal districts it is not uncommon for great cracks to appear in the house-walls, for chimneys to lean over, and buildings to fall, from the giving way of the foundations.

Both in driving a passage through the seam and in hewing the coal, the labor is much lessened by the readiness with which the coal splits in certain directions. These directions are three in number, and are called planes of cleavage.

The first are the planes of the bedding, running even with the roof and floor of the mine. The second

WORKS AT THE SURFACE OF A COAL MINE
(Copyright by Illustrations Bureau)

and third planes are at right angles to the bedding; they run from roof to floor. This natural cleavage renders it simple to hew the coal in brick-shape blocks, the long sides of which are known as the face, and the short sides, whose fracture is the least regular, are called the ends. The sides cleave bright and smooth, but the planes of bedding are dull and sooty, because of a black and fibrous powder, to which the name of mineral charcoal, and sometimes of mother-of-coal, has been given, and which lies between the planes of cleavage. Mixed with this loose substance may plainly be seen the remains of the stems and leaves of plants. Mother-of-coal soils everything it touches, and renders the miners at work, and even visitors at the workings, in a very short time as black as soot. It also ignites, instantly, in presence of a light, and some dreadful explosions in the pits, the cause of which could not be clearly traced, have been thought to be due to the firing of coal-dust.

Like Columbus in America, visitors to the coal mines land themselves in a new world. The aspect of the district is quite strange. Everything is black. Coal in huge black mounds is everywhere. Grim, skeleton arms and wheels, the tackle of the different pits, stretch out in the murky skies, hoisting and lowering the cages of coal, while dense black smoke from the furnace shafts and coking ovens obscure the sun and fill the air with flakes of soot.

Everything here is black. The scanty herbage

THE "BRIDGEPORT TRANSFER"

For the storage of coal. Capacity, 480,000 tons. Illustration used by courtesy of the Link-Belt Company, Philadelphia, Pa.

which wrestles with fate, and the few sheep which crop it, are black. The railroad trucks and roads are black. Black barges laden with coal are towed along black paths through ink-black canals.

PONIES BROUGHT UP FROM BELOW

Let us now wend our way to a large mine near, directed by lurid streams of natural gas, which are ever flaring, night and day, fed from the exhaustless stores of "bottled sunshine," as George Stephenson said, which the ancient ages placed to man's account in the deep crust of the earth. Careful scrutiny of our Davy lamps, to see them lighted and locked, goes on while the gear of the pit moves; the stout wire band or rope starts on its downward course, swift as a dart, and its twin brother mounts upwards as fast, the one freighted with a cage of miners bound for the bottom, the other with a cage of coal for the top. We look over into the dark depth. Who ever could have first thought of digging such a hole as this to see what he could find? We cannot stop to think. Our foot is on the plank, and we go "downstairs," dangling at the end of a quarter of a mile of rope.

We have been shot into one of nature's vast coal cellars, stored countless ages ago with fuel in quantities large enough to last for ages to come.

Collecting our wits, we have to leap aside to let the ponies approach with their trolleys of coal. Yes, ponies and mules are here, some fifty or more, who never see daylight, and only know of night by their hours of rest in their stables at hand.

They emerge from the gloom of tramways laid in the tunnels and from various quarters, their tramp and the creak of wheels giving notice of their approach. With no time to lose they are unyoked and yoked again to empty trucks and go back into the darkness.

The road is dry and dusty. Right and left, drifts, at intervals, lead to the workings; and the coal, still in place as it "grows," glistens in the walls. The roof is kept from falling by close massive timbers or walls of rock. The danger, strange to say, is often, not from the roof falling, but from the roadway rising. So vast is the pressure of the overlying strata that the roadway, relieved by excavation, heaves up, and with such force as to fracture the metal rails; to snap in two the thick, short trunk of a tree, put as a support, and soon to fill up the drift. The timber in a mine appears sufficient, if left there long enough, to make another bed of coal. Our passage is blocked by a trap-door; our guide asks us to wait, for the noise of wheels on the other side announces an arrival. The door opens and a truck of coal passes out, and we pass in. A rushing sound, as of floods of water, besets our path. Our friendly guide tells us it is the air to ventilate the mine. He opens the door that divides the passage, and we pass under, and the roar of mighty water ceases. We feel, however, a strong current of air setting in our own direction of traveling. We are, in fact, close to the furnace, the sole means trusted to for the ventilation of this mine. The downcast current of air from the shaft we descended moves along one side of the partition through every drift and working of the mine, driving the foul air and gases before it, and returns on the other side, driving along faster and louder as it nears the all-consuming furnace, which it feeds with the roar of the hot blast.

And what a chimney shaft, over four times as high as Bunker Hill! "Shall we go up it?" Surely our guide is poking fun at us. No; he says he generally goes upstairs that way because it is warmer. It is the upcast shaft, with cages ascending and descending the same as with the downcast. We straighten our aching

RELOADING COAL AT A COAL STORAGE PLANT

"Endless Cable" System for drilling cars. Illustration used by courtesy of the Link-Belt Company, Philadelphia, Pa.

backs in presence of the Fire King, bending low again in leaving — we cannot well do otherwise in a three-foot seam.

Here are pitmen and boys in free and easy costumes, limited as a rule to black and ragged trousers. Here a stalwart miner lies sideways at full length with his pick, under-cutting the coal, so that the upper mass comes down with a run. There another, bent upon earning as much money as he can, has worked a dangerous distance without placing props.

A group yonder, indulging in a few moments' rest, have put their lamps on the points of their picks, against orders, and long to smoke, but dare not. The officer gives a friendly word of warning, saying to some reckless one, "You never know when an accident may happen." The mine is treacherous and fiery. Explosions have cost the lives of hundreds of miners.

Remembrance of these gives a gentle sadness of tone to the man's voice, for he himself lost two fine boys in the last catastrophe. He takes us to the scene of death, now shut in from the rest of the mine. He points out where the poor charred bodies were found. The seams of coal crumble to the touch, the surface being burned by the fire.

By screwing down the flame in our lamp it will lengthen into a needle point if there is gas in the air. We try it, but no gas can be found to-day.

We ascend by the warm upcast shaft with the same curious feeling that it is the pit which moves. As the pit sinks faster and faster, it leaves us at last on top, where the wintry mists seem bright after the murky darkness of hours in the coal-pit.

Having seen how the coal is mined, we are now ready for a visit to one of the great coal storage plants. Here we see stocked immense quantities of coal, and cars laden with coal from the mines are being constantly unloaded. Again other cars are being reloaded for shipment.

All this unloading and reloading is done by means of wonderful coal handling machinery. That used here is known as the Dodge System, which is installed in plants providing for the storage of nearly four and a half million tons of anthracite coal.

It is a fascinating sight to watch the automatic reloader in operation. The coal is taken by it from the face of the pile, conveyed up the incline, and into the tower, from which it is delivered to the cars.

One of the largest coal storage plants is that of the Philadelphia & Reading Coal and Iron Company, at Abrams, Pennsylvania, which has a capacity of 480,000 tons.

# PETROLEUM

WHEN the wild Indians alone lived in our country the only way of getting a light and kindling a fire was by rubbing two pieces of wood together. Our forefathers lit their rude homes with sputtering tallow candles. Those of us who cannot have gas or electric lights can make our homes light and cheerful with kerosene oil or petroleum.

This oil had been found in many parts of the United States for many years, but it was not until August of 1859 that it was found in large quantities. At this time a boring was made at Oil Creek, Pennsylvania, and *one thousand gallons a day were drawn from it for many weeks*. The news of the discovery spread rapidly; thousands of persons flocked to the neighborhood in hopes of making a fortune by "striking oil."

In a geographical sense the history of the oil industry is interesting. Up to 1876, New York and Pennsylvania produced all the crude oil known; in 1874 almost 11,000,000 barrels, which fell below 9,000,000 in the centennial year. The two states reached their greatest production in 1891 with 33,009,236, and since that year they have gradually and steadily declined, except that in 1896 there was a gain of about a million and a half over the preceding year. For 1907, Penn-

OIL WELL

sylvania produced 9,999,306 and New York, 1,212,300 barrels, a total of 11,211,606.

In 1907, Oklahoma stood first in production in barrels; California, second; Illinois, third; Texas, fourth; Ohio, fifth; Pennsylvania, sixth; West Virginia, seventh, and Indiana, Louisiana, Kansas, New York, Kentucky and Tennessee, Colorado, Wyoming and Missouri, in their order, as stated.

When a spot has been decided on — "located" as the prospector calls it — as a likely place to find petroleum, a wooden framework, looking something like the staging put up in building a church steeple, is built over it. This is called a *derrick*, and these derricks are characteristic features of an American "oil-field." In this, or more commonly a little distance away from it, is an engine which works the drilling tools in the derrick. The hole which is drilled may be anywhere from a few hundred to two thousand or more feet deep before oil is "struck." It is usually only about eight inehes wide at the top, narrowing to about two inches at the bottom.

Sometimes the oil does not rise to the top of the well, when, of course, it has to be pumped up. At other times it runs out at the top and so forms a "flowing well." A flowing well is naturally more valuable than a "pumping well." Various ingenious contrivances are used to get the sand and broken rock out of the bore-hole; and sometimes a well has been started by exploding a dynamite cartridge at the bottom of the hole.

After all the apparatus is at hand, two or three men do all the work of making a well.

From the wells the petroleum is conveyed to storage tanks and, in the Pennsylvania region, from them through long lines of pipe (just as water is carried) to places where it is wanted. These "pipe-lines" are managed by large companies who pay the owners of the wells for the oil they take. The pipe-lines end either at places where the oil is loaded on the railroads in tank-cars — long iron cylinders — as at Tamanend and Williamsport, in Pennsylvania; or at the refineries. One of the largest pipe-lines runs for three hundred miles from Olean in Western New York to New York City.

Kerosene is made from petroleum by a process of purifying or refining, in the great refineries situated near the large cities. Other products are also obtained in this process — such as *naphtha, benzine, gasoline* — some of which are used, from their property of dissolving other things, for cleaning goods and for making paints and varnishes, as well as for giving light and heat; though for the two latter purposes not so safe as kerosene. Some of the heavier oils obtained in this refining are used in machinery to lessen the friction (lubricating). From the ill-smelling petroleum is also made the common jelly-like ointment, *vaseline.*

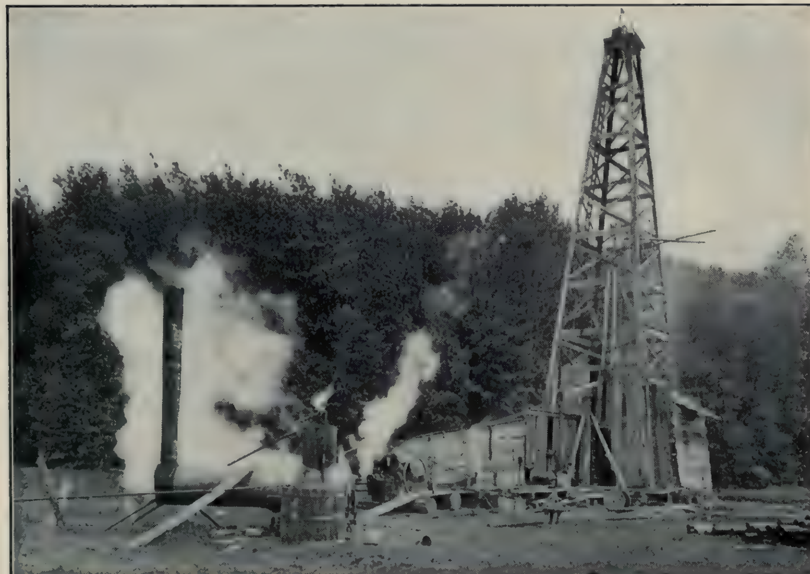
## NATURAL GAS

ALMOST every oil field produces more or less gas. This natural gas, as it is called, is used in many of the cities and towns of our country for fuel and lighting, and plays an important part in manufacturing. It is carried from the oil regions, often for long distances, by means of iron pipes.

While natural gas was not used extensively in the United States until 1872, the Chinese had made use of it for many hundreds of years, and it was carried in pipes made of bamboo.

Sometimes the gas and oil are found in the same rock and oil flows from the well, but the great gas wells do not have oil, while great oil wells often are marked by immense volumes of gas which throw the oil in large volume, sometimes, in Pennsylvania and West Virginia, amounting to several thousand barrels a day, and in Louisiana and Texas, reaching tens of thousands of barrels a day.

West Virginia is the greatest producer of natural gas in the United States. She produced, in 1911, the enormous quantity of 207,112,576,000 cubic feet of gas, valued at $28,451,907. Pennsylvania comes next, and Oklahoma, Louisiana and Kansas are great producers. Wells in these states give from 40,000,000 to 50,000,000 cubic feet a day. Texas has wells supplying from 10,000,000 to 30,000,000 cubic feet a day. These

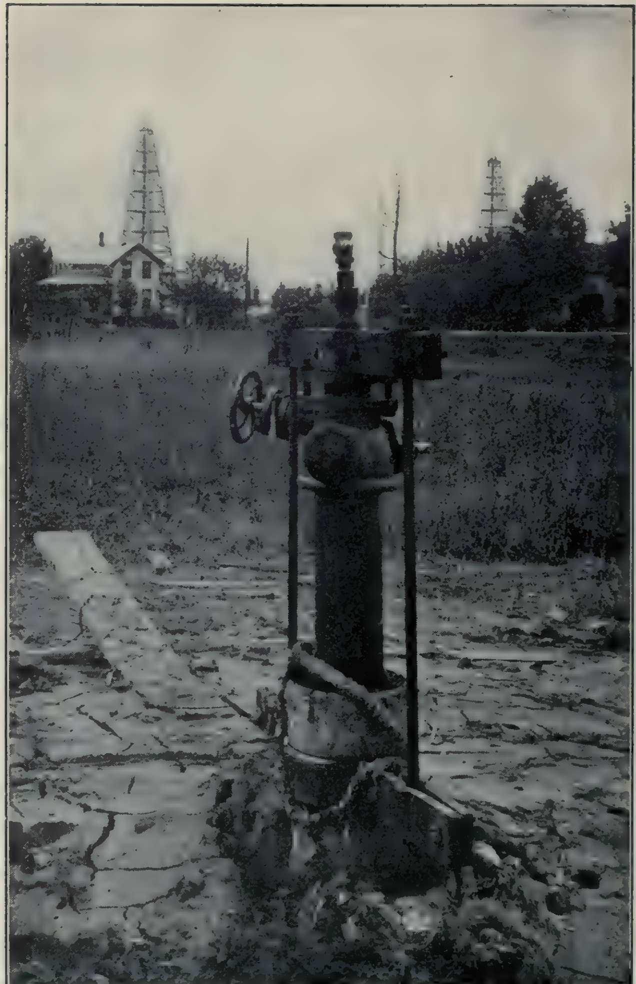


DRILLING FOR GAS

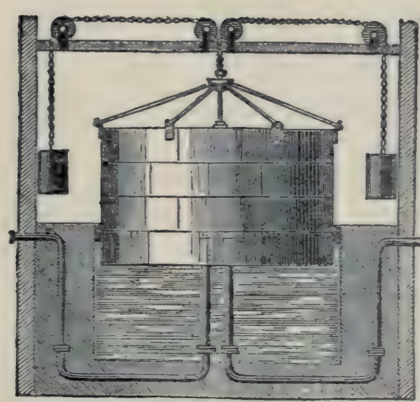
large wells are not the rule, and a well that produces a million feet a day is a good well, while in many parts of the country wells which produce from 50,000 to 100,000 cubic feet a day are rated as good property. Alabama, South Dakota, North Dakota, California, and Oregon also produce gas.

The total value of the natural gas produced in the United States for the year 1913 was $87,846,677. Much of the production is controlled by the immense pipe-line systems that are in operation in Pennsylvania and West Virginia. The Standard Oil Company's lines (The Hope), three in number, one of them an 18-inch line, carry gas from West Virginia to Cleveland, Ohio, a distance of two hundred miles. The Philadelphia Company, the Carnegie Natural Gas Company and a number of other lines carry gas into Pittsburgh for domestic consumption and manufacturing purposes, the Carnegie Company supplying the great steel mills at Pittsburgh. From the remotest ends of these lines to Pittsburgh, by rail, the distance is more than two hundred miles. In order to supply the necessary quantity for Pittsburgh, amounting to many billions of cubic feet, the gas is pumped through the lines at an average rate of forty-two miles an hour, and occasionally at as great a speed as a mile a minute.

And who were the people who discovered so many uses for all these things? They were simply people who, as school boys and as men, were *thoughtful* and "*kept their eyes open.*"



GAS WELL READY TO SUPPLY THE CONSUMER



The Gasometer.

# COAL GAS

HOW many have seen, while watching a coal fire, the jets of curling smoke bursting from a lighted coal, and every now and then blazing up with a pleasant, rushing sound. He must have been an intelligent man who first thought of catching these jets of smoke, before they lighted, and carrying them through pipes any distance, to light at the other end. Yet this simple idea led to illuminating our cities with gas. Man did not invent gas, but the mode of turning it to our comfort and welfare.

Before coal-gas was used, the towns and streets of cities were lighted with dull oil-lamps, hanging from cords or chains slung across from side to side, and our villages trusted solely to the moon, as the people still do in many country places.

As in so many of the arts, the Chinese were the first to make use of natural gas, which, a chance product of their salt wells, they applied to village lighting; but the first mention of artificial gas is in a letter of Dr. Clayton, of Crofton, England, dated 1688, published in 1739, in the "Transactions of the Royal Society," describing an inflammable spirit," resulting from the distillation of coal. The discovery, however, was treated as a scientific curiosity, and no definite use was made of the now indispensable light until about 1803, when the Lyceum Theatre in London was lighted by gas, under the direction of a Mr. Winsor. The following year a gas installation of some 3000 candle-power was put into operation in factories at Manchester, and on December 31, 1813, the success of illuminating gas was finally demonstrated by the lighting of Westminster Bridge in London.

It is interesting to note that, although just recovering from the war of 1812, the enterprising spirit of the merchants of Boston, in New England, was shown in the establishment, in 1823, scarce ten years after the lighting of Westminster Bridge, of the Boston Gas Light Company.

The principle of gas lighting is easy to test. If you fill the bowl of a clay pipe with coal dust, and plug it with clay, and then put the bowl in the fire the heat will drive out the gas through the tube or stem, when it can be lit as it escapes. On a large scale this is what is done at the gas-works. Coal is put into iron tubes, called retorts, the gas is driven off by heat, but in an impure state, being mixed with the vapors of ammonia, tar and sulphur. It has to be put through a process to rid it of impure matters which would dim its light. The dull gas first made was hardly to be compared with the clear, colorless flame which illumines our houses now.

Until the gas is wanted, it is stored in the gas-holder; this holder is in two parts, the tank, and the holder proper. The tank is a pit in the shape of a cylinder, which is kept filled with water to prevent leakage of the gas. The holder is above the tank, and is filled with gas. Great care has to be taken to prevent explosions. These do sometimes happen despite caution, shaking the district for miles around and often destroying life.

The wonderful powers of coal do not end at gas.

After the coal has been heated and the gas removed, there is left a black, porous, hard, but brittle matter. This is called *coke*. The gas companies sell it for fuel. It makes a quick, hot fire.

Other things produced in the manufacture of gas and coke are the valuable *coal-tar* products, from which manufacturing chemists make many beautiful colors known as *aniline dyes*. In fact, to-day, popular interest in coal-tar is centered mainly in these dyestuffs and other refined drugs and chemicals also derived from it.

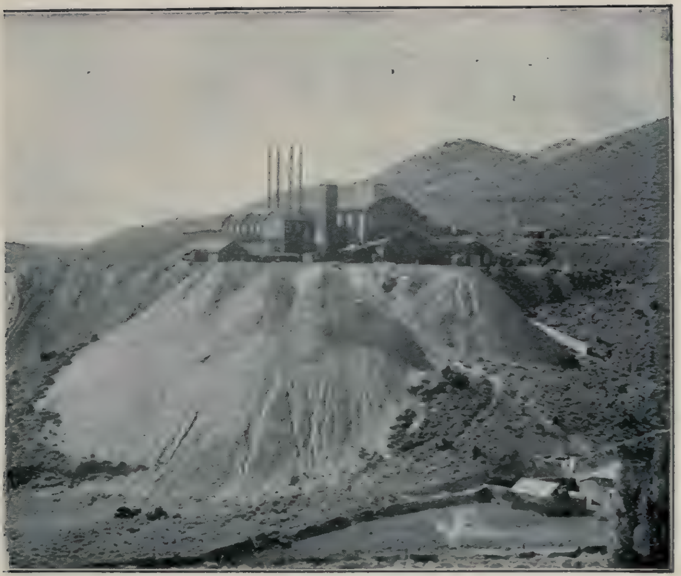
Numerous industries are now closely dependent upon the use of these dyestuffs. To the great textile branches they are almost as essential as their supplies of vegetable or animal fibers. The same condition exists in the paint, varnish, and ink trades, and a group of minor industries. The old-time natural dyestuffs, such as indigo, madder, cochineal, and a score more, have no longer an extended use, with the exception of logwood, mineral colors, with some inconsiderable exceptions, such as Prussian blue in silks and iron buff in khaki.

Artificial dyestuffs, derived from coal-tar products, have displaced nearly all rivals, combining qualities of fastness, ease of application, brilliancy, variety of shades, etc., utterly unknown to the former generation of dyers.

The United States, however, for commercial reasons has developed little manufacture of these products, and has been dependent upon European nations for the bulk of her supply.

In considering why this condition exists there must be borne in mind the fact that only a small part of coal tar (about ten per cent) can be made into drugs and dyes. The other ninety per cent, suited only for the manufacture of pitches and various heavy oils, forms the basis of an industry already well developed in the United States. Increased development of an industry based on only ten per cent of the tar or on 0.5 per cent of the original coal must depend, in important measure, upon advantageous commercial disposal of the other ninety per cent of the tar or the other 99.5 per cent of the coal.

The United States has the raw material, namely, high-grade coal, in great abundance and of a kind well suited for making all the tar products in the country.



A GOLD MINE

## METALS

THE best known metals are gold, silver, iron, lead, copper, zinc and tin. Sir Humphrey Davy, the great English chemist, proved that all the common earths and alkalies have metals for their base, and can be reduced from the matrix, or earthly substance in which they are imbedded. These metals are elements or simple bodies. Some of them we have learned to extract cheaply, and they are much used in the arts. Others remain rare and costly, awaiting our further knowledge before entering into man's service.

When alloyed with copper, or tin, aluminum produces a bronze, better than any other mixed metal in use, for ship fittings, sheathing, steam propellers, and for the manufacture of artillery.

Gold and silver are called precious metals, because they do not corrode or waste in melting, and on account of their great scarcity and value. Another metal, platinum, is like the precious metals in these respects. The more common metals, but iron in particular, are often distinguished as the useful metals.

Metals are spread over the whole earth; iron being the oftenest met with, and gold the next. Gold is found native or pure, though sometimes mixed with silver, copper, or mercury. The common metals are so blended with earths, that they have to undergo a series of transformations before they are obtained in their pure state, ready for man's service and wants. Much knowledge, which it took many ages to gain, is required in the successive operations of reducing the ore to the state of pure metal. Iron, in particular, is very stubborn and difficult to treat. Its ores lay unapplied during the whole history of the most ancient nations.

Metals form a very large part of the earth's mass. It has been reckoned that one-third by weight consists of metallic ores, while five per cent of the lower rocks and a higher rate of the upper rocks, are iron. The water of the ocean also holds most or all of the metals in solution.

Water, in fact, is the grand agent which has played its part in the deposit of metals, whether in vast beds of ironstone, or veins of other metals which fill the crevices of rocks — whether in small quantities widely diffused, or in abundance in spots as widely apart.

Water makes its way through the earth to its greatest depths, and is the cause of the ceaseless changes which the rocks undergo. Water filters or strains through the surface soil, or operates in currents beneath, under enormous pressure. No rock, not even the hardest crystal, is free from water, which appears to make its passage the more easily the greater the depth. It is met with in the deepest mines, and the hewer of stone is as familiar with the "quarry water" as with the stone he works. An ocean of water, equal to the ocean which fills the great hollows of the earth's surface, or that other ocean of vapor which fills the air, is absorbed by the crust of the earth as by a sponge. Water is the universal solvent. Give it time, heat and pressure, and no element can withstand its influence.

A principle rules in nature whereby atoms, or particles of a like kind, attract each other. Atoms of metals, held in solution by water, may travel many miles, before meeting with the proper conditions to unite with their kind.

AN OPEN CUT

Showing two tunnel mouths (*a*), the tracks on which the cars are run, and a fair idea of the rock formation.

WEIGHING THE BARS OF BULLION
(By courtesy of *Scientific American*)

# GOLD

THIS precious metal is mined in every quarter of the globe. But California, Alaska, South Africa and Australia have, in the immensity of their gold production, overshadowed that of the rest of the world, either in ancient or modern days. Gold is discovered in the sand and mud of rivers; it has been, by the action of the water, brought down from its home where it formed in the mountains. Often it is found in the veins or lodes in quartz rocks, with iron pyrites.

It takes the form either of grains or nuggets or solid masses of metal. In any case it is mixed with or encrusted with earth and alloy. The earthy part can be removed by water. In old times in California this used to be done in pans or in what the miners called a "cradle" — a box on rockers and open at one end. But this slow process is now done away with; hydraulic engines and sluices taking the place of the first rude implements. If the gold is embedded in quartz the rock must be crushed to powder before washing. This crushing is done in different ways in different countries, but most of the quartz of California is reduced by a machine called the stamp mill. When at last the heavy metal is crushed and washed free from earth it is further purified by being treated with mercury or quicksilver; this mercury is afterward driven off by heat, leaving a mass of spongy gold behind, which is afterward run into ingots or bars, called "bullion" in commerce.

Gold plays an important part in history. There must have been lavish stores in the days of the early oriental empires, whose extravagances both profane and sacred histories picture. In olden times there was great abundance of the precious metal in Asia, and many legends and tales were told about it.

In January, 1848, gold was discovered in California. The news spread over both hemispheres. Excited multitudes poured in from Mexico, the South American coast, the Atlantic States, and from all parts of Europe. San Francisco, a station of a few inhabitants, sprang in a few years to a splendid city of 50,000 people. Its harbor was filled with the fleets of all nations, and the State of California counted three millions of souls. A mania for gold seized young and old, to the neglect of all other industries. Food, clothing and the common necessities of life rose to fabulous prices. Gold so fixed men's thoughts, that the rich mines of silver and cinnabar (ore of quicksilver), of plumbago or black lead, of manganese, copper, iron, and coal, were thought nothing of, and passed over. After a few years, the gold fever yielded to healthier industries and the resources of California began to be wrought. Tillage of the soil was resumed, and the finest grains and fruits were raised. Farming now flourishes, and the golden harvests of this grand region prove a source of wealth, less variable than the washings of its blue clay or the crushings of its quartz reef.

In times long gone by, a sheep could be bought for a few pence, and laborers worked for a *penny a day;* that was because gold was so scarce that a great deal had to be given in exchange for it. Now that gold is more plentiful, wages have risen and our daily wants cost many times as much as in the days of its scarcity. In most countries gold is now the only legal money; silver and bronze being

COMPRESSED AIR DRILL
Used in drilling holes for blasting in the quartz mines.

coined for convenience as tokens to represent the fractions of the gold coin.

But all gold is not made into money. Science, art and commerce make new and large demands upon the supply every year, while bills of exchange and bank checks lessen our need of coin. The amount of gold, therefore, coined at the Mints into money is only a very small part of the gold produced.

The minting or coining of gold is kept closely in the hands of governments. The buildings where the coining is done are called Mints.

A writer in an interesting article in an issue of *Scientific American* thus explains the process of marketing gold:

"Suppose that you owned a gold mine. What would you do with the gold? In the ordinary commercial lines the marketing of the product depends upon ability to place it before the people, and involves the meeting of competition, adjustment of freight rates and the surmounting of numerous little difficulties, all of which have a bearing upon the ultimate result of your undertaking. With gold it is different. Uncle Sam stands ready to buy all of the gold brought to his mints or assay offices.

"There are three coinage mints where you would be able to dispose of your bullion, *viz.*, Philadelphia, Denver, and San Francisco. Should it happen that your mine was not located convenient to any of these mints, you would find United States assay offices at Boise, Idaho; Carson, Nevada; Charlotte, North

"A HOIST"

The machinery used n lifting cars of ore, men, etc , from the lower levels of the mine. This machinery was taken into the mine piecemeal and set up in a room blasted out of solid rock.

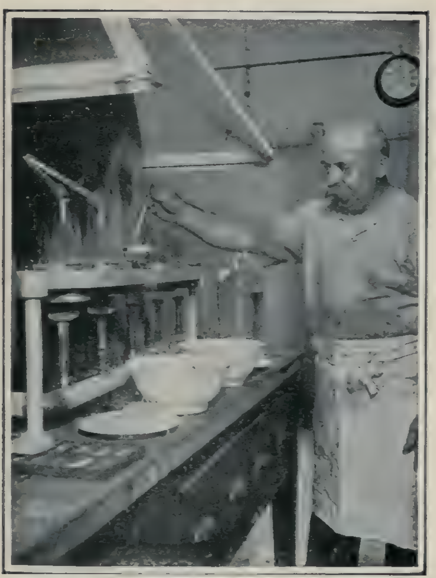
Carolina; Deadwood, South Dakota; Helena, Montana; New Orleans, Louisiana; New York City; Salt Lake, Utah; and Seattle, Washington. At these institutions gold bullion is purchased and forwarded to the mints.

"You would take your gold into the office and watch it weighed upon a pair of balances so sensitive that although they had several hundred pounds in each pan, one one-hundredth of an ounce would be indicated. Having weighed your gold, the officials would issue you a receipt for it which you would keep until you received your check or coin in payment. Your gold would then have become what is known in the office as a "deposit." This deposit, with many others like it, would be turned over to the melting department, where, in a specially constructed furnace, it would be melted in a plumbago crucible and poured into a suitable mold. Simple as this may sound, the melting of gold is a very serious and difficult task. The high heat which it is necessary to generate in order to melt the metal necessitates a furnace constructed of the finest material. These furnaces are usually operated by gas or oil and are built of the very finest grade of fire brick and fire clay. The plumbago crucible which is used is composed of graphite (the same material that comprises the center of your lead pencil), a little fire clay and a little sand. In the manufacture of these crucibles great care must be taken to secure a uniform mixture of the parts, so that when heated no portion of the vessel will expand more than any other portion. Unequal expansion would cause cracking.

"The crucibles are fashioned in molds and dried, or burned in kilns, after a fashion similar to dishes or bricks. They are made in all sizes, from those having the capacity of an after-dinner coffee cup to immense sizes holding over twelve gallons.

"Gold coming direct from a mine is never pure. It may contain various base metals, the nature of which depends upon the process by which the gold was obtained. Gold from stamp mills contains some iron, very likely some copper and often some quicksilver. From cyanide mills the bullion nearly always contains zinc, as this metal is made use of in the process. The zinc, too, may also have contained impurities, some of which will very likely be in the resulting bullion. Copper has some of the characteristics of gold, so that if copper is contained in the original ore some of it will be very likely contained in the bullion. Silver is always associated with gold in the ores of the latter. The amounts may vary greatly, but it may be stated that silver is always present in gold ores.

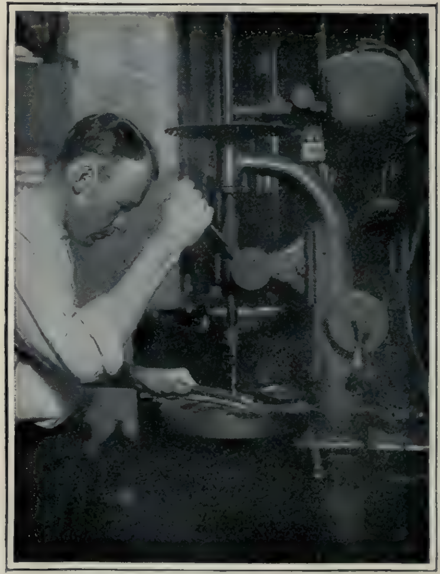
"The problem of the melter who handles the deposits at the assay office is to make from the deposit a bar of bullion of a perfect mixture from top to bottom and from end to end of the gold and other metals. In order to do this he places in the crucible with the deposit a stated amount of flux, varying with the size and composition of the deposit. The virtue of this flux is to remove a certain portion of the base metals and likewise to form a molten mass over the top of the bullion which will prevent volatilization of the precious metals. It is lighter in specific gravity than the metal and rises to the surface of the melt. For clean bullion



REMOVING GOLD ASSAYS FROM BOILING APPARATUS
(By courtesy of *Scientific American*)

the flux is composed usually of borax. Perhaps some little soda will be added. For bars which contain five or ten percent or more of the base metals the flux will be comprised more largely of soda. This is just the ordinary soda which is used with sour milk to make biscuits or other dainties.

"The molds into which the gold is poured are made of iron and a full stock of the various sizes is kept on hand so that no matter what the size of the deposit a bar will be turned out with a width approximately twice its depth and a length about twice the width.



BORING A BAR FOR SAMPLES
(By courtesy of *Scientific American*)

Into this receptacle the melter pours the contents of the crucible. The metal sinks to the bottom, and the slag, as the flux is known after it has passed through the process, rises to the top. After the metal and slag have solidified the mold is overturned, the slag separated from the bar, the bar cleaned and weighed. In order that the depositor may receive pay for every bit of gold which properly belongs to him, the inside of the crucible is scraped clean and the slag treated by being crushed to powder and panned in a miner's gold pan.

"The weight of the granules which have been recovered from the slag is added to the weight of the bar, and this amount is the weight of bullion for which the depositor is paid. It is then the assayer's business to determine the proportions of gold, silver and base metal in the bar. These proportions are reported in thousandths. He obtains a sample by means of a special clipping machine designed for the purpose.

"A complicated chemical process is necessary to determine the fineness of this sample. It cannot be described in detail here. Suffice it to say that the process is based upon the fact that from an alloy of gold and silver in which silver predominates in the ratio of about three to one it is possible to dissolve the silver by nitric acid, leaving the pure gold behind.

"The assayer having completed his work, reports the fineness of the bar and the clerical force gets busy on the calculation of its value. Knowing the weight of the bar and the proportions of gold and silver it is a mere matter of figures to arrive at its value. This done, you are given either a check or United States coin upon surrendering the receipt which was given you when you deposited your bullion."

## SILVER

SILVER is the whitest and most lustrous of all the metals, as well as the most malleable. Its grain is so close and clings so firmly, that beaten silver spreads out into a leaf two-and-a-half times thinner than that of gold. The metal is ductile, too, and the wire, drawn out into marvelous fineness, is in great demand for silver lace. When pure, silver is a soft metal, but hardens when with alloy.

Veins and masses of it occur all over the earth. In Mexico the richest workings are in connection with a single vein which is one hundred and fifty feet wide. It is rarely found pure, and then in only small quantities. In nearly all silver ore there is some gold, and in nearly all gold ore, some silver; silver is often found with lead, copper, mercury, and cobalt.

Different countries use different ways of extracting the pure silver from the ore. The ore, generally a dark colored rock, has to be crushed, washed, and treated with chemicals to obtain the silver in it.

The chief silver-producing countries are the United States, Mexico, Canada, and Australia. Mt. Potosi in Bolivia, 2697 feet above the level of the plain of the city of Potosi, has been mined up to within one hundred and twenty-five feet of the summit and seems to be almost a mass of silver ore.

The great silver mining industry of the United States had no existence before 1860. The gold seekers, who wandered over the Western States between the years 1850 to 1860 looking for gold, discovered the silver unexpectedly.

One of the greatest silver mines ever known, the Comstock mine at Virginia City, Nevada, was found in this way, about 1859, by two men, James Shinney and Henry Comstock. Not knowing the value of their great discovery, it is said that they sold it for a trifle.

See how useful a little knowledge is to us, often at unexpected times!

After this it soon came to be known that the mountains of Colorado were full of similar veins.

Pure silver is too soft to make durable coins or vessels which shall be light and firm. This is remedied by alloying it with a little copper. Almost all of what we call "silver" articles are formed of this alloy.

The great use for silver, apart from coin, is for plate. A great deal of silver is now used in electroplating, so that silver-plated articles are enjoyed in tens of thousands of homes where solid silver could never be hoped for.

A COPPER CONVERTER CARRYING THE METAL TO THE SMELTER

# COPPER

THE baser or common metals, as all but silver and gold are called, make up in quantity for what they lack in quality. The United States is well supplied with metallic treasures, both in beds, as those of iron-stone, and in veins or lodes, as those of copper and lead. The metallic veins, almost without exception, run east and west; descend to unknown depths, and dip or incline their planes of surface north and south. This, of course, makes easier the work of hunting for metal; it also leads us to think that magnetic action has had something to do with the deposit. These veins look like the cracks in clay soil, split open by the heat of the summer suns, and are filled sometimes with metallic ores.

Copper was certainly one of the first metals subdued by man. Combined with the tin which the Phœnicians obtained from Cornwall, in England, it became the brass of the ancients. This was not the same compound metal which we call brass — which is made from a mixture of copper and zinc — but was more properly bronze, capable of taking a keen edge, suited to cutting instruments and weapons of war. Corinth was famous for its works in brass. At the destruction of that city so many statues were melted that the streets, it is said, *ran with molten brass*, and the compound was long afterward celebrated as Corinthian metal.

The Colossus of Rhodes was an image of bronze, weighing 320 tons, striding across, from bank to bank, an inlet of the sea, and under the legs of which ships could sail with their masts standing. This Colossus was thrown down by an earthquake. Bronze was for many ages employed by the Egyptians, Greeks, Romans and the Chinese. It was this alloy which gave the name to the Bronze Period; the age between the earliest historical division of time, called the Stone Period, and that of the Iron Period, which came after.

The Incas of Peru made an alloy of tin and copper

REDUCTION WORKS AT BUTTE, MONTANA

(By courtesy of the Northern Pacific Railway) so hard and durable that it was used for tools to cut the stones for their immense aqueducts and temples.

In America, the French Jesuits were the first white men to enter the Lake Superior region. According to their accounts, the Indians had been mining copper for many years before the Europeans came.

A century later, an Englishman who knew something of copper mining, in his book of "Travels," mentions a mass of copper which he found near the mouth of the Ontonagon River. This mass may now be seen at the Smithsonian Institute.

Mr. Rickard, in his book on "The Copper Mines of Lake Superior," mentions the fact that the white men who first penetrated the forests of its shores, found evidence that a people more advanced in their methods than were the Indians, evidently had worked these mines. In his book is a remarkable illustration of a mass of copper, taken from a pit something like twenty feet deep, at McCargo's Cove, on Isle Royale. The mass shows the marks of stone hammers or hatchets.

Fortunately, for the world's progress, copper is the most widely spread of all metals, and may readily be combined with other metals, thus forming compounds of more usefulness than copper itself.

The demands of tubes and pipes, of electrical apparatus, of brass and bronze, and of the industries dependent on the various copper salts, have actually compelled the world to double its output in the last ten or fifteen years. One hardly realizes the omnipresence of "copper" until one makes a simple experiment. Count, for instance, the different kinds of brass articles in an ordinary sitting-room: one soon runs up into the twenties and thirties. And then remember that a single factory will make thirty thousand *different* articles, and that there are scores of such firms — which, after all, is a mere incident in the world of copper. It is fortunate, therefore, that the metal is one of wide distribution.

The immense increase of the world's output of copper corresponds closely and naturally with the great development of the iron and steel trade of the last twenty or thirty years. And with the increased demand have marched improvements in methods of extraction which may be said to have revolutionized this branch of the industry. Ore in Michigan is now fed into a cupola in the morning and shipped as "99 per cent bars" in the evening — an operation which formerly took four months to complete. Thirty years ago it took a ton of coal in Colorado to smelt two and a half tons of copper ore; now the same works make the ton of coal smelt nearly four tons of ore.

Copper ore is troublesome to reduce. Smelting includes many and long operations of washing and melting the ore, and refining and toughening the metal.

The total result is to be seen in a comparison of the copper output figures for 1900–1913 with those of the preceding years. The world's annual production at the beginning of the nineteenth century was well under 10,000 tons, and it did not reach 50,000 until the late fifties. In the seventies it first passed 100,000, and in the concluding years of the century it averaged just less than half what it is now. The amount for 1913 was over 1,000,000 tons.

The change in the comparative importance of the countries supplying the copper is quite as striking as the change in the aspect of the figures of supply. For years Russia was the main source of supply for Europe. Then came Chile in the early sixties. By 1867 Chile was responsible for 70 per cent of the world's output, and it was still leading in 1880. But its "out-of-the-way" geography, and the great discoveries of the United States and Mexico, effectually relegated Chile to the background, and it has now to be satisfied with the sixth or seventh place. Nothing is more striking, in the figures of the world's total, than the preponderance of the United States output — over 500,000 tons, or 50 per cent. Mexico is now third on the list, Japan having gained second place as a copper producing country, with an output in 1913, of over 80,000 tons.

Of the immense American supply three states alone — Arizona, Montana, and Michigan, in the order named — supply between 70 and 80 per cent. The Michigan mines are the oldest, and their copper is the purest. The largest and most modern smelting plant in the world is located at Anaconda, Montana.

"Seeking the story of copper the writer," says the editor of *Cottrell's Magazine*, "went to the northern peninsula of Michigan recently where Lake Superior copper is produced.

"There are many rich copper regions in this country; the products of each are valuable for general purposes; each has its particular problems and displays the wondrous works of man, so in treating this particular one no comparisons are intended, but it is selected rather by reason of its nearness.

"As in the final production of all metals, copper involves three industries — mining or taking the ore or rock out of the earth; separating the actual metal from the rock, and smelting, which involves not only a refining process, but also casting the metal for shipment.

"The Lake Superior copper region is that part of Michigan that juts out into Lake Superior, and where it is cut off from the southern portion by the Portage River, Portage Lake and a ship canal.

"It is about 150 miles long and from one to eight miles wide. About 114 miles of this have been prospected and its general copper-producing possibilities are well known.

"From 1869 to 1873 private enterprise built the Portage ship canal from Portage Lake to Lake Superior at a cost of $2,500,000. This was finally acquired by the government, which then began the dredging of the Portage River, that not only rendered Houghton and Hancock, the two cities on opposite sides of the river, available to the largest ship tonnage and around which the copper industry centers, but also provided a shelter harbor for shipping from the storms of the lake.

"This government improvement is of vast importance for the reason that the copper industry is dependent on Ohio, Pennsylvania, West Virginia and other southern territory for coal, and it is rendered accessible to the world's cheapest form of large tonnage shipments.

"Coming through the Portage on a lake boat, and in nearing Houghton and Hancock, mining shafts begin to stand out against the sky on the high hills along the river like well derricks in an oil country, except that all or nearly all the shafts are producing. The hills are honey-combed with shafts and tunnels, and the city of Hancock is over a mine five thousand feet below its lowest point.

"There have been sixty years of scientific mining in this district, and many of the original shafts are still in use and some are very deep — the Calumet Hecla Mining Company, for instance, has one shaft straight down for more than a mile and a half, while the Quincy has another running down the same depth at an angle of 45°.

"Many of the older and larger companies have more than one and frequently many shafts.

"Some idea of the extent of the tunneling under these hills can be gained by a statement of one of the engineering corps at the Quincy mine in saying that he had been with the company more than thirty years and that there were parts of the mine that neither he nor any other present employee of the company had ever been in.

"The mines in the region are all dry and free from gases so that the loosening of the ore, or rock, as it is called by mining men, is a simple question of drilling and blasting — no artificial ventilation being required save in the very deep mines.

"The removal of the rock is naturally a large mechanical and electrical proposition for economically handling it, and involving special power problems. Aside from an extended underground trolley system of railways there is the lifting of the rock to the surface, and the power required for a drum of sufficient size to wind a mile and a half of steel cable can be imagined — the "dead" load alone of the cable itself is enormous, to say nothing of the live load or rock that it is required to lift.

"The Calumet and Hecla mines have one engine of 8000 horsepower and another of 4000 horsepower. Many of the parts of the larger engine, particularly the main shaft and connecting rods, were forged at the Krupp Gun Works, at Essen, Germany.

"Mass or native copper is found among the rock seams frequently weighing five hundred tons or more, and while not in all mines is so large a tonnage, yet in all to a small extent. It is highly desirable in this form, for it is almost pure copper, and can be sent direct to a smelter and put into a refining furnace without the intervention of concentrating or even a blast furnace — just the surface rock removed with a sledge or steam hammer.

"It is the theory that the rock in the bowels of the earth fused with the copper while the rock was in a lava state, leaving the mass copper in the seams.

"Bolivia, in South America, is the only other copper country in the world where native copper is found in quantities of any commercial importance.

"All the material brought to the surface in the Michigan copper region contains about two and one-half pounds of pure copper to the ton and this includes mass copper. Mass copper is very largely found in the Quincy mine near Hancock and it is rarely found in the Calumet & Hecla mine only seventeen miles distant, yet the latter property maintains its two and one-half pounds to the ton in its rock product.

"Mills, called concentrators, where the rock is stamped and the copper separated from rock, are all located on the neighboring small lakes and rivers and at the foot of hillsides, in order to obtain water and conveniently dispose of the tailings or waste.

"Concentrating is based on the very simple principle that metal is heavier than rock — the copper goes to the bottom when water is applied in what is really a system of washing.

"From the storage bin of the rock house at the mines on the hilltops the rock is hauled to the stamp mills. Here it is dropped into large bins on the uphill side of the mill. From these bins the rock is run through chutes to the steam stamps, the larger, cleaner pieces of pure copper being first removed by hand.

"Steam stamps are heavy Corliss engine steam hammers operating in steel mortars and hitting a blow of three or four tons a hundred times a minute, reducing the rock to a size of a three-eighths mesh screen and finer.

"The larger modern stamps will crush from five hundred to seven hundred tons of rock in twenty-four hours.

"It is stated at the Isle of Royale Mine concentrating plant that the copper is taken out of the rock within fourteen hundredths of one percent — in other words, only this amount of copper goes out onto the dump.

"At the smelter the copper rock undergoes about the same general treatment as in reducing iron ore to pig iron. This first melting gives two products, slag and impure copper. The slag is run to waste as sand.

"The impure copper is run into another furnace of the puddling type like those used in rolling mills, for refining, which consists in boiling the mass, and the impurities are carried off as gases.

"The slag from this refining furnace being rich in metal it is returned to the blast furnace, and the copper is drawn off and cast, either mechanically or by hand, into ingots, or wire bars, ready for the world's markets."

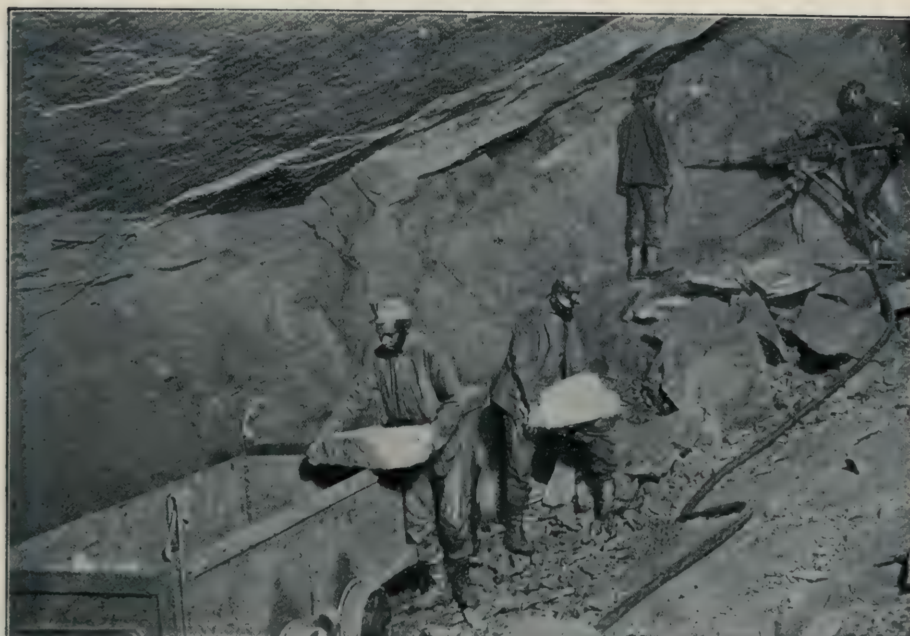
RUFFNOR IRON MINE, ALABAMA
Showing entrance to mine where ore beds are exposed

# IRON

THE stores of iron ore are not a new or recent gift of Nature. The iron was in the rocks for ages before our land was peopled. In England the smelting of iron succeeded that of tin. The Romans practiced the art.

The wars and manners of mediæval times gave great scope to the skill of the iron workers. Great pains was bestowed by the sword-smiths and armorers upon their work, some of which has been kept until now, and cannot be excelled.

The first horse-shoer lived in the Middle Ages; before his time horses were shod with leather. As



IRON MINE — TYPICAL UNDERGROUND MINING OPERATIONS
Courtesy Tennessee Coal and Iron Co.

new highways were made, farmers' wagons, never thought of when the roads were few and bad, brought the wheel-wright and coach-smith forward with their need of iron.

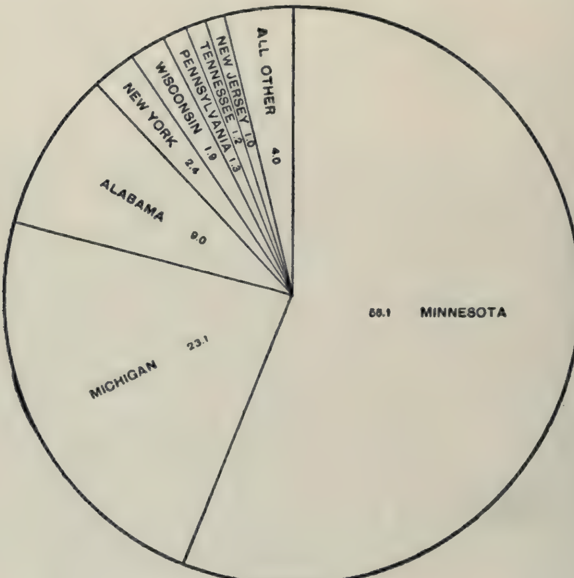
Without the forging of iron, Pascal, who lived in the seventeenth century, would not have had the idea of a wheelbarrow.

When he invented a wheelbarrow to save the toil of carrying heavy baskets, he little thought that his humble invention was the germ of the world's great

GIANT GIRDER
187 feet 'ong. Weight nearly 120 tons

wheel traffic of to-day. Iron gave birth to traffic on wheels; wheels widened interchange, and interchange has brought us the knowledge of the world in which we live. It has been well said that iron and coal are kings of the earth.

Iron is of a bluish-white color, and is very brilliant when polished. It is harder than most other metals, and increases in hardness when changed into steel. Almost every mineral contains some iron; all over the world it is found, but the United States has an iron industry, unexcelled by that of any other land.




PER CENT PRODUCTION OF IRON ORE, BY STATES; 1909

In our country the States in which ores of iron are found most abundantly, are: Minnesota, Michigan, Alabama, New York, Wisconsin, Pennsylvania, Tennessee and New Jersey.

Sometimes the iron mine is just a huge ditch; then it is called an *open cut* mine. At other times openings called *shafts* are dug straight downward; from the bottom or sides of these shafts tunnels called *drifts* are made in different directions; these drifts are what are called underground mines. (See map of Red Mountain, Alabama, on the next page.) The ore, loosened

OPEN CUT IRON MINE, BIRMINGHAM, ALABAMA

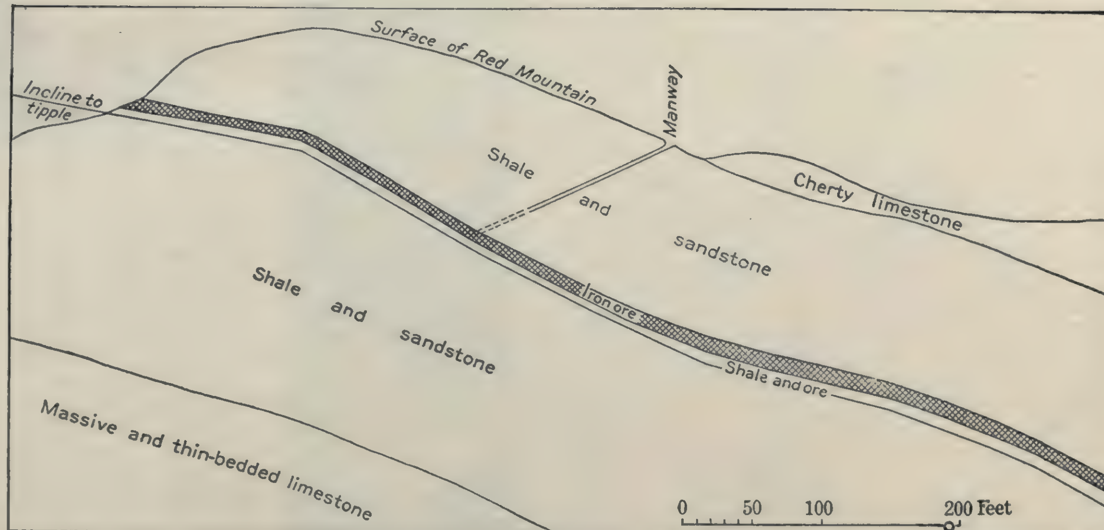
by the miners with pick-axes or by blasting, is drawn out of the mine and sent to the furnace to be smelted. All iron ores go through processes of reduction.

The three most common ores are:

*Magnetite,* which is black and magnetic.

*Hematite,* which is dull red and not magnetic.

*Limonite,* which is yellowish or dark brown in color.




PROFILE MAP OF RED MOUNTAIN, ALABAMA

The magnetites, hematites and limonites are believed to represent different stages of development in the alteration of the same mineral substance.

The Lake Superior district, which comprises Minnesota, Wisconsin, and Michigan, and the Southern district, which comprises Alabama, Georgia, and Tennesee, are the principal producing districts, the combined production of these two districts representing 91.9 per cent of the total tonnage of ore used by the operators in their own blast furnaces or sold in the market.

The predominance of the Lake Superior district in the iron-mining industry is shown conspicuously by the chart on page 66. More than four-fifths of the ore used and sold in 1909 came from this district, and the value of this ore, including by-products, represented nearly seven-eighths of the total for the country.

From magnetite iron is made the finest iron and the best of steel.

Take a piece of magnetite, pulverize it with a hammer, then hold a magnet over it. The little black particles of iron are drawn up to the magnet, leaving the sand particles behind.

But think how long it would take, working in this way, to get enough iron to make one iron kettle, or even one iron shovel! In order to supply the world with iron, whole mountains must be reduced to dust, and the iron ore often has to be separated from four or five times its weight of sand. Then it must be put into such form that it can be shipped and smelted.

CHARGING A FURNACE WITH MOLTEN IRON FROM MIXER

For ages men have thought about and improved upon ways of mining and working iron. Just what you did with the hammer and magnet, scientific men have done on a grand scale. They devised wonderful giant rollers, with sharp spiked teeth, which move so rapidly that great rocks are crushed by sheer force of motion.

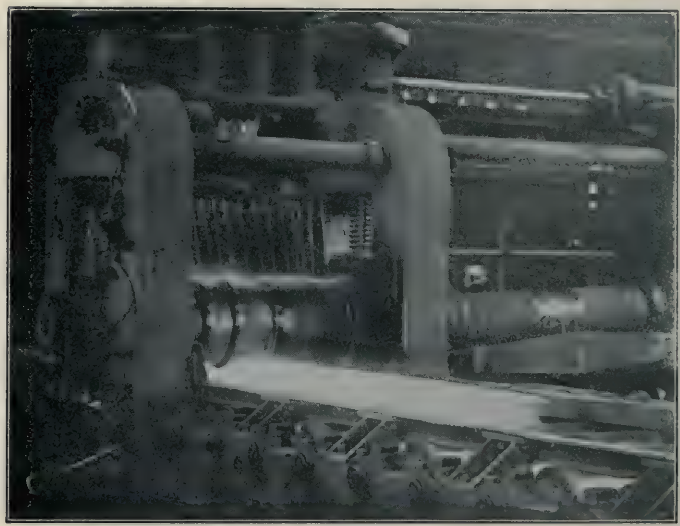
The crushed rock, reduced to dust, is hoisted by steam to the cupola of what is known as the magnet house. Part way down the chute of this magnet house are nearly five hundred magnets, which can "pull" hard enough to lift a big cannon high up in the air. When the dust comes tumbling down, these magnets pull the iron particles over to where they can fall down one chute, while the unattracted sand particles fall down another.

The iron dust runs down into the blower room, where the "hot blast" blows it free of what few impurities may remain. Then it goes into the great cylinders, or mixers, and from there to the furnace. The furnace is charged with the melted iron from a great pot, which is lifted and poured by means of an overhead electric crane. When the iron is cast it is run into a main channel, called a sow, and also into smaller sidings, called pigs, from a fancied resemblance to that animal with a litter of young ones.

Sow and pig iron are of three qualities. The best is gray iron; the second mottled, and the third white. These qualities and consequent values are derived as much from the fuel and mode of smelting as from the character of the ores. Foundry iron needs no further preparation for castings, the best quality running into the most delicate and beautiful tracery.

Cast iron is brittle and breaks under the hammer. In order to convert it into wrought, bar, forged, or malleable iron, it has to be refined by remelting with coke or charcoal; this process drives off any oxygen and carbon which may have been left, and brings it to the state of fine metal, losing about a tenth in weight.

Cast iron was not in common use before the year 1700, when Abraham Darby, of England, thought that iron might, in many cases, take the place of brass in founding. He had in his service a Welsh shepherd boy, named John Thomas. While looking on during the experiments, the shepherd boy thought he saw



INGOT BEING ROLLED INTO BLOOM AT HOMESTEAD WORKS

where Darby missed his mark and begged to be allowed to try. The two remained alone in the work-shop all night, struggling with the stubborn metal and poor molds, but, just at dawn, they succeeded in casting an iron pot, and another of the great secrets of nature was solved. For more than a hundred years after the night when Darby and Thomas cast the first iron pot in a mold of sand contained in frames with air-holes, these two of our world's benefactors and their descendants pursued the same process and kept the secret, with plugged keyholes and barred doors, at the since famous iron-works of Colebrooke Dale, England.

Some of the greatest inventions of human genius and thought divide King Iron's history into epochs.

MODERN BLAST FURNACES, SHOWING ORE STOCK AND FURNACE, AS SEEN FROM THE CHARGING SIDE (Carnegie Steel Co.)

The first of these was the cupola or dome-shaped furnace, devised by Cort in 1784. The object he succeeded in was to cause the flame, instead of acting directly upon the mass of metal, to curve around the roof, and play upon the surface of the charge. The puddler, who conducts the operation, constantly stirs the charge laid upon the floor of the furnace, so that every part, in turn, shall be presented to the oxygen of the blast, and the carbon of the iron shall be quite consumed. This puddling or stirring is, perhaps, the hardest manual labor known to industry. It is done by men, working nearly naked, because of the glowing heat. They keep stirring the fluid metal, until it loses the liquid condition and assumes that of a pasty mass, which they work up into balls or blooms, and ladle out of the furnace. An engine, during the whole time, sends a blast of air forward, which cannot be arrested for a moment without injury to the metal. While the puddlers stir the sticky blooms about, so that each lump may come to the flame, they must change their rakes from time to time, so that they, too, may not melt. Such furious heat plays so upon the puddlers that their eyes get bleared, and their faces blistered.

Now puddling by machinery has, in a great measure, taken the place of manual labor. American inventors have contrived revolving furnaces. A "squeezer" does all the dreadful back-breaking, and the rotary furnace turns out four times as many blooms as by hand labor. Science has come forward at a time when the men, knowing how quickly puddling killed them, had begun to abandon their trade. We shall now be able to get bar iron without having to think of "the martyrs whom the fire slew."

In 1829, Nelson introduced the hot blast in place of a cold blast, and brought air to the metal, at once ready for the work it had to do. As a result, the yield of metal increased at the rate of two to one, and a better quality of iron was gained, in less time, and with smaller consumption of coal. Until the

BESSEMER CONVERTER
Converting fift.en tons of iron into steel in about ten minutes
(Carnegie Steel Co., Ohio Works)

invention of the hot blast, the moisture in the air that played on the metal had been an endless trouble and source of uncertainty in puddling — more so in summer than in winter, from the larger amount of moisture absorbed by the warm and dry air.

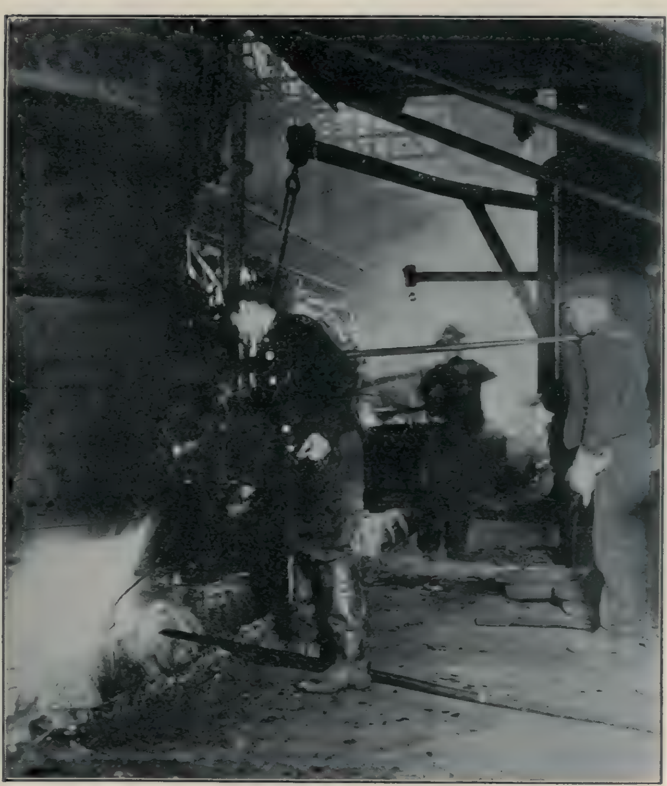
In 1855, a man named Bessemer invented a method of forcing currents of air or of steam among the particles of molten iron. This process made the metal malleable and gave it some of the qualities of cast steel. So simple is the process that we wonder why it had not been thought of before.

GENERAL DROP FORGE

Come into the steel-works of Pittsburgh. What a whirr and clatter and roar!

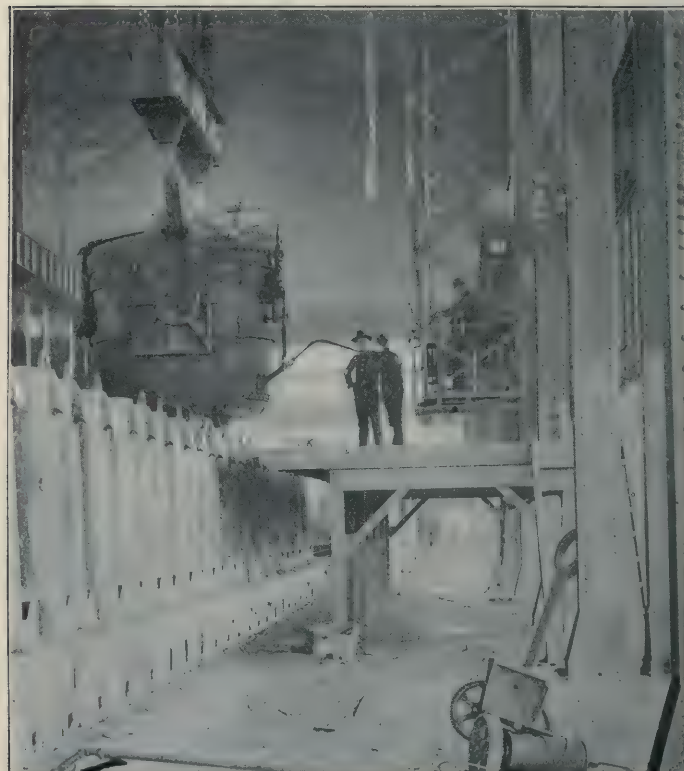
Iron works upon iron. Here are steam-boilers sputtering, and engines cutting, sawing, hammering, planing, slotting, sliding, drilling, turning metal. We witness a scene without equal in the realms of industry. It makes one's eyes open wide, to see tools play upon iron as if it were an easy yielding thing. Resistance appears no more to be thought of than if it were clay.

On the summit of a blast furnace, a hundred feet



SAMPLING THE STEEL WHILE THE MOLTEN METAL IS RUNNING INTO THE MOLD
(Carnegie Steel Co.)

high, the sweltering heat can hardly be borne, as it rises from the sandy gridiron below, into whose narrow gullies the red-hot metal runs, from the open sluice at the foot of the iron tower. Yet men learn to sustain the fiery heat, which overhangs the white-hot plate,



CASTING STEEL INGOTS

the "wagon" filled with tons of molten steel, and the molds into which the pig iron crawls crimson-red from the furnace. In the rolling-mills, huge blocks of white-hot metal, beautiful with greenish vapor-like flame, are hauled around; thrust into the jaws of the rolling-machine, passed many times to and fro, and finally brought out as armor-plates or steel rails.

Trip-hammers pound, engines puff and rattle. See

STRUCTURAL MILL, LOADING YARD AND STOCK YARD, HOMESTEAD WORKS, CARNEGIE STEEL COMPANY

how the furnaces glow with white heat, and how the heated iron or steel flashes as it is drawn out!

Immense shears are here, too, clipping great sheets of iron.

Over there vast grindstones are smoothing and polishing long lines of shafting.

Looking up, we see traveling along, suspended by great chains from an overhead electric crane, an immense pot, or "ladle," as it is called here. This ladle has been filled at the furnaces with fifty tons of melted metal, which is to be cast into blocks, or ingots, of steel.

The ladle is halted directly over the ingot molds — large flasks made of cast iron. Then a man standing on a nearby platform, by means of a long lever, opens a hole in the bottom of the ladle. Through this hole a stream of melted steel pours into the ingot molds.

After the ingots are cast, they then go through the several processes by which steel is made ready for the many purposes for which it is used.

Now come into the factory among the forges and smiths. Here are the riveters at work, bolting together the iron sheets of a steam boiler, or the massive plates of a huge ship's hull. Hammers, striking by the hundred, keep up a cling and a clang that forbid speech. As a city is built, one brick at a time, so a boiler or a hull draws nearer completion with every driven bolt.

Labor it is in the true sense, heavy, hard, manual labor with an end in view, and that end, *human welfare.* Nothing else is properly labor.

## IRON AND STEEL INDUSTRY

Steel works and rolling mills constitute one of the largest industries in the country, the total value of products for 1909 being $985,722,534, The number of establishments was 446, and the number of persons engaged in that industry was 260,762, of whom 240,076 were wage-earners, the amount paid in wages being $163,200,758.

The industry is concentrated largely in the Middle Atlantic and East North Central States, and in the Panhandle of West Virginia. Of the 446 establishments in 1909, 362 or 81.2 percent, were located in seven contiguous States—New York, New Jersey, Pennsylvania, West Virginia, Ohio, Indiana and Illinois. The value of products in these seven States amounted to $897,365,567, or 91 percent of the total for the United States.

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## STEEL PRODUCTION BY STATES

Figures for the production of steel by States show that the most important of these, in 1909, in order of rank, were New York, Colorado, Maryland, Alabama, West Virginia and Kentucky. There was a relative decline from 1899 in the importance of Pennsylvania and Illinois as producers of steel and a relative gain in that of Ohio and Indiana. In Indiana practically all, and in Pennsylvania much the larger part of the steel produced in 1909 was made by the open-hearth process, but in Illinois and Ohio the Bessemer process still predominated.

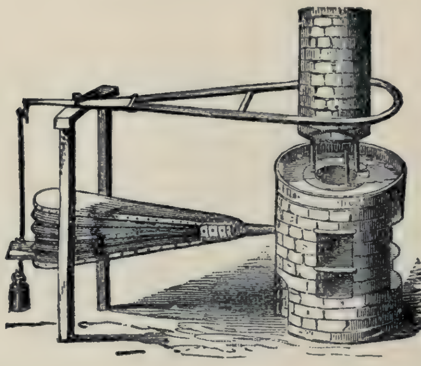
## SOME OF IRON'S CHILDREN

**Knives.** That beautiful pocket-knife you treasure had quite a history before it came to you. Separate pieces of steel — which, you remember, is only iron hardened — were pounded and pounded until they were closely welded together in one piece in the shape of a long, narrow bar. The bar was perhaps half an inch in breadth, and about as thick as the back of your knife-blade. The forger took this bar, heated it, and began pounding again. The bar was next cut into short strips; each of these strips — your blade among the rest — was then ground upon dry stone and thus made considerably lighter in weight. Then a piece of iron for the "tang" or shoulder — the iron middle of the handle — was welded on. Back to the forge went the shaped blade again where the maker's name or mark was stamped upon it. To make it still harder, it was heated to a cherry red and suddenly plunged into cold water.

Next came the grinding upon wet stones; with every turn of the round stone the firm blade grew thinner, till, at last, it was "sharp" enough and ready to be polished. The polishing was done on wheels covered with leather and fine emery. The blade, bright and shining, was at last riveted into the ivory bone or horn part of the handle, and lo! there was your knife ready for the store-keeper and for you.

**Needles.** That needle which Jennie is using to piece together the bright bits of patch-work might tell, if it could speak, a very interesting story — a story of how steel wire was drawn out fine and in great lengths; of the wire being wound in large coils until it was cut with great, powerful shears into lengths each sufficient for two needles; of these lengths, curved because of having been coiled, being straightened by being packed in bundles — a thousand or more in one bundle — within two strong, iron rings.

Of how the bundles were heated red-hot, and then placed on an iron plate having two parallel grooves, and worked backward and forward by the pressure of an oblong iron tool — of how the lengths came out of this process perfectly straight and even and were sent to the pointer. How the pointer "sharpened" both ends of the lengths of wire on a swiftly revolving grind-stone. Of how each wire was stamped in the centre by means of dies, with the grooved and rounded impressions of two needle heads; how these were perforated by fine steel punches. How these double needles, about one hundred at a time, were threaded together by fine steel wires passing through the eyes, making them look like fine-toothed combs; how the joinings of the pairs of heads were at last broken by bending. How each tiny head had to be smoothed and rounded before the wire was removed, and the needles, perfect at last, are sent out to do their work in the world.



OLD NAIL FORGE

**Nail Making.** The nail could tell a story that would please you, boys. A story of a great machine fed with hot strips of steel of the right breadth and thickness for nails. Of the way the machine "bites" the strips into the right lengths, clutches them by the neck as they fall, and holds them until it has "banged" the upper end into a head; a machine *which turns out from 100 to 1000 nails in a minute.* Who do you suppose invented such a hurrying, banging instrument as this? *American people, of course.*

But all nails are not made by machinery. Cast nails are made by running melted metal into sand molds; some horseshoe nails are still made by hand, forged upon the anvil. Long ago, when every nail had to be made by hand in Europe, not only the men, but their wives and children worked all day in filthy sheds close by their homes. The nail master or overseer supplied them with nail rods and paid them for the work done; sometimes in money, sometimes in "truck."

The nail factories of our land are chiefly in Massachusetts, New York, Connecticut, and the Schuylkill region of Pennsylvania.

There are about three hundred sorts of nails altogether, each of ten different sizes; from the smallest brads and tacks to the heavy rivets and bolts; in all, some three thousand varieties. Nails were made before iron was worked; the first ones being made of bronze. Bronze nails were found in the ruins of Pompeii.

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**Sewing Machines.** Old King Iron has so many children right here in our own country, all working away for us in the agricultural and commercial world, that the names and pictures of half of them would more than fill this book. There are hundreds upon hundreds of sewing-machine manufactories, but we will look into one in New York.

Here we are in one of the machine rooms; here lathe-work, milling, grinding and drilling are being noisily carried on, until all parts of the machine are exactly fitted and properly finished.

Every separate piece has to be inspected and gauged before it can be passed along as perfect.

Many of the working parts of the machine are of hardened steel, so that they shall not wear away easily.

Before the machine can be put together the legs and iron parts are given that hard, polished, black surface by a process called japanning.

This work is done in a room by itself. The japan mixture is put on with a brush in several coats. Between each coat they are put into ovens and baked for ten or fifteen hours.

After this process, the pieces to be ornamented go to another department, where decorations in painting, bronzing or gold-leaf are put on, or decalcomanie pictures transferred to them.

In a room called the "assembly" room, all the work done upon the machine, in the putting together of its parts, is looked over, except that of setting up the tables on their stands.

Near by, is still another room, where "jacking" is carried on. This is simply placing the machines, while being put together, upon jacks and setting them to "running" at a great speed to see if the parts will work. After this each machine is set to sewing a little to see if it is capable of doing the work for which it is intended when it shall go out into the world.

The first attempts at devising the sewing machine were made somewhere about the year 1830, but these were unsuccessful, and the inventors died without gaining any benefit from their labors.

In 1843, Elias Howe, of Massachusetts, invented a machine, which, after many trials, hampered with excessive poverty, he at length succeeded in bringing into use, in 1846.

The story of this man's career, which you would do well to read, is a striking chapter in the annals of intelligent labor, and well illustrates what perseverance will do, by carrying out its purpose through disappointment, hindrance, and want of means, till at length success is reached in spite of everything.

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**Stoves.** Come into the kitchen and you will meet with one of the most useful of Iron's children. "Oh, yes, the stove!" you have thought, long before I could write the word.

The pattern of the stove is first made in wood; from this an iron casting is taken, which, after a great deal of filling and fitting up, is used as a working-pattern. These iron patterns are backed with wood in the same room where the "flasks" or boxes containing the sand for the molds are made.

The greatest care must be taken to make every part of the pattern evenly balanced in weight, else the castings made from it will be warped and cracked by the heat. Impressions of this pattern are made in the sand in the flasks or boxes.

The melted iron is carried by hand from the furnace, poured into the molds, or boxes of sand, and allowed to cool.

All the work, except the rough, heavy pieces for heaters and furnaces, goes from the molds to the cleaning room.

In this room they are turned about in revolving drums nearly as large as hogsheads. This is to rub off all the sand left upon the iron. Some of this work is done by hand, the men using stiff steel wire brushes.

The iron is next taken to the polishing room, where the pieces are made bright and beautiful by being ground upon emery wheels and polished upon leather-covered wooden ones.

The nickel-plated parts were polished on these leather-covered wheels and taken to be plated in a room by themselves. A quantity of nickel, a metal something like iron and cobalt, is melted in water, and acid is added. After some further preparation the pieces are put in and the liquid is brought to boiling. In a few minutes the objects are completely coated and are taken out to be burnished on wheels covered with felt and muslin.

In the "mounting" room the stoves are all put together; the parts being made to fit evenly and work nicely.

The making of machines themselves by machinery was an invention of our American people, and in many of our great cities are immense factories where wheels, boilers, bolts, all the parts of locomotives, flour mills, mining machinery, shafting, hangers and pulleys, and hundreds of similar articles are made.

There are several such manufacturing firms in Ohio, which sends its machines to every State in the Union and to many foreign countries.

STRUCTURAL STEEL WORK ON A MODERN SKYSCRAPER

## MORE ABOUT IRON

NOW if you were interested in reading about the little ones, we will look at some of the larger of King Iron's children. The armor-plates which clothe our warships; the eighty or one hundred ton steel guns with which the vessels are armed; the huge steel beams and girders used in the construction of the modern "sky-scraper" now so common in our great cities; the iron railroad bridges which cross broad rivers and arms of the sea; the monstrous shafts and giant fly-wheels which regulate whole systems of mill


PLACING STEEL GIRDER OF RAILROAD BRIDGE

work, the slabs and masses, rolled, wrought, or twisted — all these are the products of the steam hammer. This monster can strike his blows with a force to which no limit can be found, yet he can be so perfectly controlled as to crack a nut without injuring the meat. As the great masses, many tons in weight, move up and down, they look like anvils more than hammers, or rather a dozen anvils welded into one. Down they

DROP FORGE

come with a thud that shakes the ground and scatters thousands of bright sparks. But all steam hammers are not large; the principle works just as well in a small one.

Tremendous double iron rollers, some twelve feet long, and a yard in girth, relieve the steam hammer of plate work. Without teeth, they bite the sheet of glowing iron with their gums, and the force of their grip is proved by the effect upon the metal, which goes in thick, and comes out thin, as though it were lead. Backwards and forwards a number of times, and the end is an armor plate, twelve to fifteen inches

JOINING THE "ANGLE BEAMS" ON A "SKYSCRAPER"

thick; or a thin sheet, for the tin-plate worker, for the making of pots and pans.

So much do the beauty, strength and perfect working of a machine depend upon its being exactly right, that the fitting-shop of a machinist, where the bright parts of an engine are burnished and every part is examined and tried, is a picture to dazzle the eye and amaze the senses. One can scarcely believe that the movements of wheels and pulleys, repeated by thousands; with their leather bands depending or stretching from them, over and under, around and about, in and

MACHINE SHOP AT WORKS OF UNITED SHOE MACHINERY COMPANY, BEVERLY, MASS.

out and everywhere, are merely the tools at work for making engines and frames, and not the finished machinery of a mill. Lathes, planes, and other tools, themselves the product of similar tools, work as if they thought and planned. A ceiling to the room exists only in fancy, for the roof is but a mass of pulleys; tackle after tackle, the counterparts of each other, and to each tackle a whirring lathe beneath. Each tool has its own duty and goes about it in the din without interfering with its neighbor.

In one place, an immense tube, big enough for a water main, is peeling itself as it revolves against a sharp tool, and leaves a fanciful heap of iron ribbons or ringlets. Over yonder the tire of a locomotive driving-wheel revolves. Can it be real iron? With each turn, the circumference gets nearer to the centre by a quarter of an inch. Stop and think what that means. It means that a strip of iron is simply scraped off all around as the wheel turns. Get an iron wheel and a sharp chisel and take off a like circlet a quarter of an inch thick. That will tell you what this lathe does.

## SONG OF THE FORGE

Clang, clang! the massive anvils ring;
Clang, clang! a hundred hammers swing;
Like the thunder-rattle of a tropic sky,
The blows still multiply — Clang, clang!
Say, brothers of the dusky brow,
What are your strong arms forging now?

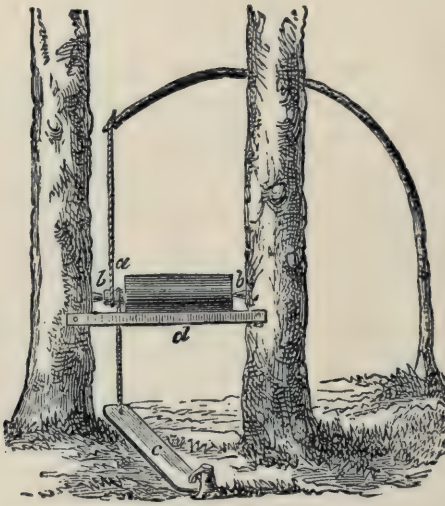
. . .

Clank, clank! — we forge the giant chain
Which bears the gallant vessel's strain
'Mid stormy winds and adverse tides.
Secured by this, the good ship braves
The rocky roadstead and the waves
Which thunder on her sides.

. . .

Clang, clang! a burning torrent, clear
And brilliant, of bright sparks is poured
Around and up in the dusky air
As our hammers forge the sword.

The Sword! a name of dread; yet when
Upon the freeman's thigh 'tis bound,
While for his altar and his hearth,
While for the land that gave him birth,
The war-drums roll, the trumpets sound —
How sacred is it then!




ANCIENT LATHE

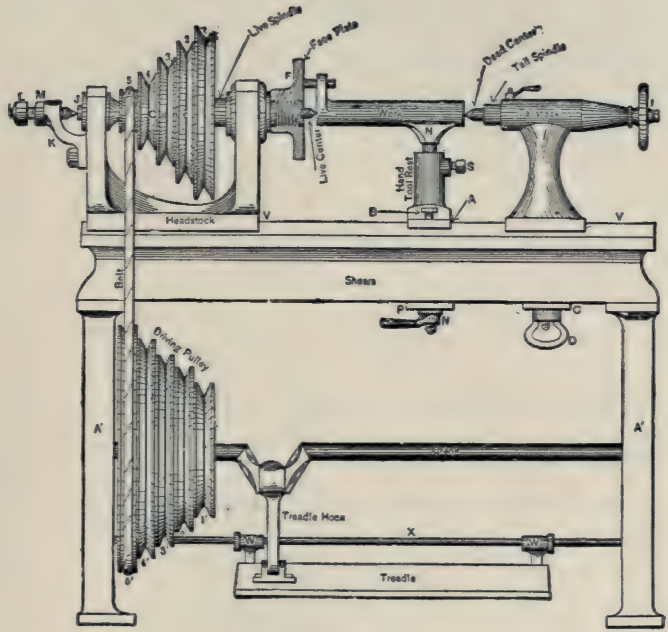
## THE LATHE

BUT what *is* the *lathe*, do you ask, which seems to play so important a part in so many manufactures?

We do not know when or by whom the lathe was first used, but we do know that an ancient Asiatic nation, living among the Carpathians, used to produce vases with the use of such a lathe as you see in this picture.

The piece of wood to be shaped was held by the pointed plugs of wood (*b*, *b*). A cord was tied to a slender tree, passed around one end of the work (*a*), and tied to the treadle (*c*).

Moving the treadle up and down made the piece of wood turn round and round while the workman held a




FOOT LATHE

sharp cutting-tool against it, soon forming it into an even, graceful shape.

Think of a small decimal fraction multiplied and multiplied by itself till it has grown away up among the whole numbers. This ancient, rude affair is the decimal which ingenuity has multiplied into the powerful machines of to-day.

The simplest lathe used in civilized countries is the foot-lathe.

The treadle, moved by the foot, pulls the driving pulley around. The driving pulley moves the belt; the belt moves the top pulley, which whirls the "live spindle" around with it. The spindle, revolving, turns the work around.

The lathe family is very large. Some move by hand; some by steam power, and are capable of cutting metal as well as wood.

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Let us be content to work,
To do the thing we can, and not presume
To fret because 'tis little. 'Twill employ
Seven men, they say, to make a perfect pin,
Who makes the head consents to miss the point;
Who makes the point agrees to leave the head;
And if a man should cry, "I want a pin,
And I must have it straightway, head and point,"
His wisdom is not worth the pin he wants.

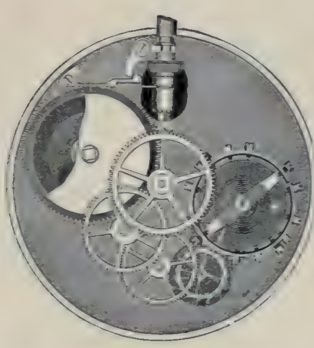
— *Mrs. E. B. Browning*

NEW YORK SHIPBUILDING COMPANY'S PLANT, CAMDEN, N. J.

## IRON

Iron vessels cross the ocean,
Iron engines give them motion;
Iron needles northward veering,
Iron tillers vessels steering;
Iron pipe our gas delivers,
Iron bridges span our rivers;
Iron pens are used for writing,
Iron ink our thoughts inditing;
Iron stoves for cooking victuals,
Iron ovens, pots, and kettles;
Iron horses draw our loads,
Iron rails compose our roads;
Iron anchors hold in sands,
Iron bolts, and rods, and bands;
Iron houses, iron walls,
Iron cannon, iron balls;
Iron axes, knives and chains,
Iron augers, saws and planes;
Iron globules in our blood,
Iron particles in food;
Iron lightning-rods on spires,
Iron telegraphic wires;
Iron hammers, nails and screws —
Iron everything we use.

**PARTS OF ONE 16 SIZE WALTHAM WATCH MOVEMENT — ACTUAL SIZE.**
**(Illustration used by courtesy of Waltham Watch Company.)**



# WATCHES AND CLOCKS

WHETHER you are so fortunate as to own a watch, or whether you only hope to own one some day, I think you will like to learn something of its manufacture. Few of you young folks, we are sure, are so thoughtless as never to have wondered at the mechanism of the patient house clock. Clocks are believed to have been in use as early as the twelfth century.

Long years ago — in the sixteenth century — before watches had been thought of, and when clocks were very imperfect affairs, that great thinker, Galileo, was one day sitting in a cathedral. As he sat there he noticed that a lamp, hanging by a slender chain from the top of the building, was swinging steadily to and fro.

This set him thinking. He went home, made a pendulum and set it swinging in the same manner. He found its motions so exact and steady that by counting the number of times it moved backward and forward it might be used as an instrument for dividing periods of time. He found, too, that two pendulums of the same length would beat time exactly together; and that a short pendulum moved to and fro more times in a given period than did a long pendulum.

Of course these pendulums could not be used for clocks — no such idea entered his head, so far as we can find out — because there was no way to keep them going except by "jogging" them, now and then, with the finger; and there was no way to mark the time except by counting; but they did very well for marking the time when making calculations in astronomy, and for that they were used for many years.

But the pendulum once invented, some clever men long afterward thought out a way to keep it going and to mark the time upon a dial.

If we look at the inside of one of our clocks, we shall find it has all these parts: frame, wheels, pinions, pendulum, and weight. But a clock with weights will not "go" unless it is kept in an upright position; so thinking, ingenious men set to work to invent a pocket time-piece that would keep time in any position. At last they produced the watch, which, as you well know, regulates the motion of its wheels, not by a pendulum, but by the heavy metal wheel called the *balance*.

The work of manufacturing watches by machinery was commenced in the United States in 1850. After four years of preparation, during which time a few hundred watch movements were made, the original watch factory of America was put in operation at Waltham, Mass. The two-story factory, erected in 1854, has gradually been replaced by the group of immense five-story buildings which constitutes the largest watch factory in the world, known as the Waltham Watch Factory. At Elgin, Ill., there is another large watch manufacturing plant, and a number of smaller ones in various cities of the United States.

All the minute parts of these most wonderful little time-pieces are made by machinery. Simple wires of steel, plates of brass, and ingots of gold and silver are used. One machine punches a plain round piece of brass; another makes it a skeleton wheel; a third cuts the teeth on a score of wheels; yet another polishes it; then it goes into a room where it is immersed in a solution of gold, thus gilding it; and it comes out one of those beautiful little wheels which you see moving so exactly on its pivot in the completed watch.

Another apparatus is used to fashion the escapement wheels, with their oddly-turned teeth, and the compensation balance, the most conspicuous of all the wheels of a watch, with its two sections, held together by a thin, diametrical bar of steel, and its outer and inner rims of brass and steel. This compensation balance is one of the most important inventions in the modern watch, as the different degrees of the contraction, or expansion, by cold or heat, of the copper and steel rims, keep the balance constant in all temperatures. No piece, however small, is put into a watch until it has been measured and weighed. There is also a gauging machine for measuring thickness, and still another machine measures the hair springs.

One of the most interesting rooms is that in which the dials, or white faces of the watches, are made. These are at first plain, round copper pieces, cut out of the sheets by machinery. A preparation of white enamel is spread over this copper piece; and when it is dry it is inserted into a red-hot oven, where the enamel is fused hard on the copper. It is then ground with fine sand and again subjected to fire to give it the glossy appearance which we see on the watch's face.


## PENS AND PENCILS.

I HOPE you have wiped the steel pen lying there on your desk, Nellie, for it was a great deal of work to make it. First, steel had to be rolled into thin sheets, cut into broad strips, heated, scoured and rolled again. Then each strip had to be cut into blanks by a "cutting-out machine"; one or more holes were then stamped in each blank as well as the name of the maker. Next the blank was curved by stamping. The nibs had to be made by grinding on an emery wheel; the slits made by peculiarly shaped chisel-stampers. Then the pens were heated and scoured, and placed in a revolving cylinder over a hot fire to give them that fine bronze color.

The lead pencil: — do you take it up and wonder if that, too, has a history? It has. You would not think that the part which is soft enough to "mark with" was a *kind of hardened coal,* would you? It is, and it is called graphite or plumbago. It is a formation of coal from which all the gases have been driven by heat and pressure in the earth's crust. This graphite — black lead, we call it sometimes, but it has nothing of metallic lead in it at all — is to boys and girls best known in the shape of that very useful article, the lead-pencil. But the chemist also uses it mixed with fire clay to make his crucibles; the engineer uses it, finely powdered, to lubricate his machinery; and the housekeeper uses it to polish her stoves to keep them from rusting.

"There is not a very remote antiquity to the lead pencil. Some old parchments are known that were marked with lead ruling, but this must have been metallic lead. LeMoine, a writer of the year 1537, speaks of documents marked with graphite. Other writers have found papers which were evidently written with a piece of graphite inserted in the end of a stick. This shows the evolution of the pencil, beginning with the use of a piece of graphite in connection with a stick.

"The first pencil factory in America was founded by a school girl. There was a graphite mine in England at that time, called the Barrowdale Mine. This school girl, from somewhere, obtained some of these pieces, and anticipated quite closely the pencil method of modern days. In some way she crushed the graphite, either with a hammer or a stone, and then employed gum, mixing the two together; then she cut an alder twig, dug the pulp out, and stuffed the little alder cylinder full of this gum and graphite, and thus produced the first lead pencil made in America. This took place in Danvers, Massachusetts. Later a man by the name of Joseph W. Wade co-operated with this girl, and together they made a number of lead pencils after the same fashion.

"After Mr. Wade came one Monroe, who made pencils first at Concord, N. H. They were fairly well made and answered the purpose, and became articles of commerce at that time. About the same time the well-known literary man, Henry D. Thoreau, of Concord, Mass., made pencils. Thoreau was an impecunious man, always poor, always in trouble for lack of ready money, sometimes in debt, and at one time was put in jail for not paying his taxes. After he got his pencil business started, his friends said: 'Now there will be an end to Henry's poverty,' but he dropped the work about as soon as he commenced it, and said he could not afford to spend his time on something that was already finished. If he could have seen the lead pencils of to-day, he would not have thought that he had worked out to its full completion the evolution of the lead pencil. This happened somewhere about 1820 or 1825, in Concord, Mass.

"After him came a man by the name of Wood. Wood associated himself with Monroe. Wood was a very clever fellow, an inventor and originator of clever machinery, and made some circular saws and knives which he set to work on pencil making. In that way he anticipated some of the up-to-date features of the present pencil machinery.

"Joseph Dixon, the founder of the Joseph Dixon Crucible Company, about this time also made lead pencils after the same system. They have some in their office yet, that he made at that time. This practically completes the beginning of lead pencil making in the United States.

"The Barrowdale Mine of England was the source of the graphite, and the pieces of graphite quarried were said to be in such form that they could be sawn and pressed into the wood. It could easily be foreseen, however, that pieces of this kind were not very numerous. It then occurred to a Frenchman by the name of Conte, to powder the graphite and put it together with a binding material, and he worked at it until he produced the graphite part of the pencil, substantially as it is made now. Not much, however, was done with it, either by Conte or by any other Frenchman. The Germans then took it up, and while this Frenchman was the originator of this system, to the Germans belongs the credit of working it out and putting it into its present shape.

"Concerning the coming of the Germans to America, Faber came first in 1861; the second American factory was founded by what is known as the American Lead

Pencil Company. They started in 1864. In 1868, the Eagle Pencil Company transferred their interests here, and in 1872, the Dixon Company started.

"The work of pencil-making is ingenious and attractive, and a nice exhibit of mechanical talent. The number of raw materials used is between forty and fifty, and the whole world contributes to the assembling of the raw materials.

"The Dixon Graphite Mines are located at Ticonderoga, in the northern part of New York State, and the Dixon Cedar Mill is located in South Florida. They are so far apart that one day in the winter of 1904, when the mercury at the graphite mines was 40° below zero, the temperature at the Cedar mill was at 70° above. These graphite mines produce about 130 tons of rock and graphite every day, and the machinery for producing this is very large and consists of an elaborate system of crushing stamps and washing mills. The graphite is carefully separated from the rock before being sent to Jersey City. The first step in Jersey City is to get all the grit out of it. It goes through the process of washing and sifting, through many machines, until it is passed upon as absolutely perfect. The clay, which is the binding material, is treated in the same way. The clay is mined in Germany. It is cleaned and made ready for the mixture by an elaborate cleaning and sifting process. By a combination of the two, the so-called lead is produced, and by the blending of the two the grades are produced.

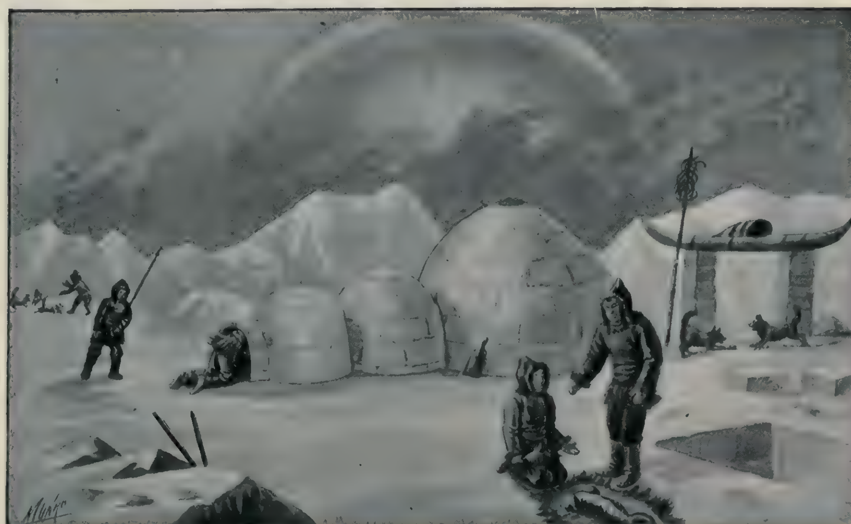
The more graphite and the less clay, the softer the pencil; the more clay and the less graphite, the harder the pencil. In this way the various grades are produced, running all the way from very, very soft, until you reach the very, very hard. The soft leads are made larger than the hard ones, to obtain in that way the necessary tensile strength. When the mixture is perfected, it is put into a very heavy hydraulic machine, the bottom of which is full of holes. Heavy pressure is brought to bear and the mixture is forced through these holes and falls into a tub below. This is repeated time after time, until judgment assures the worker that it is well kneaded. Then it is put through a similar machine, with a single hole in the bottom. As it is passed through this single hole, it comes out as strong as a shoe-string. The next step is laying these leads out on a board, 21 inches long, and when dry they are cut into lengths 7 inches long, placed in a crucible, sealed up, and baked in the kiln, where the temperature reaches 2200° or 2300° Fahr. After being taken from the kiln they are ready then to be placed in the wood.

"The colored leads go through the same process, with the exception that a China clay is used for the binding material and the pigments are used instead of graphite, to give the different colors. It is the same way also with the so-called copying leads, where aniline is substituted for the graphite.

"The wood, as we have mentioned before, is cut in

Florida. The logs grow there. The consumption of cedar logs suitable for pencils is going on at a greater rate than the growth. One of these days, cedar will be a thing of the past. The pencil people have to be fore-handed in supplying themselves with a large quantity of cedar, to protect themselves against any contingency."

So you see that for the commonest things, which we use daily without a thought, we may be indebted to the labor of people in many far-away lands.



ESKIMO IGLOO

# THE STORY OF YOUR HOUSE

A SUITABLE shelter for himself and family has always occupied the most serious thought of man. In fact, a nation's civilization is often gauged by its advance in architecture, by the style of its buildings and monuments. As man advanced more and more in knowledge, so he desired a better and still better home.

In the days before man had any written history, we are told that whole races burrowed under ground or scooped out caves for dwellings in the rocks.

The Indians of North America lived in wigwams, rude structures made of the skins of animals or of the barks of the trees of the forests.

The Arabs and many Tartar tribes of Asia wander from place to place depending on the tents for shelter.

In the far North the Eskimos in the winter build their homes of snow, as the best material to keep out the cold. In fact, climate and suitable material has,

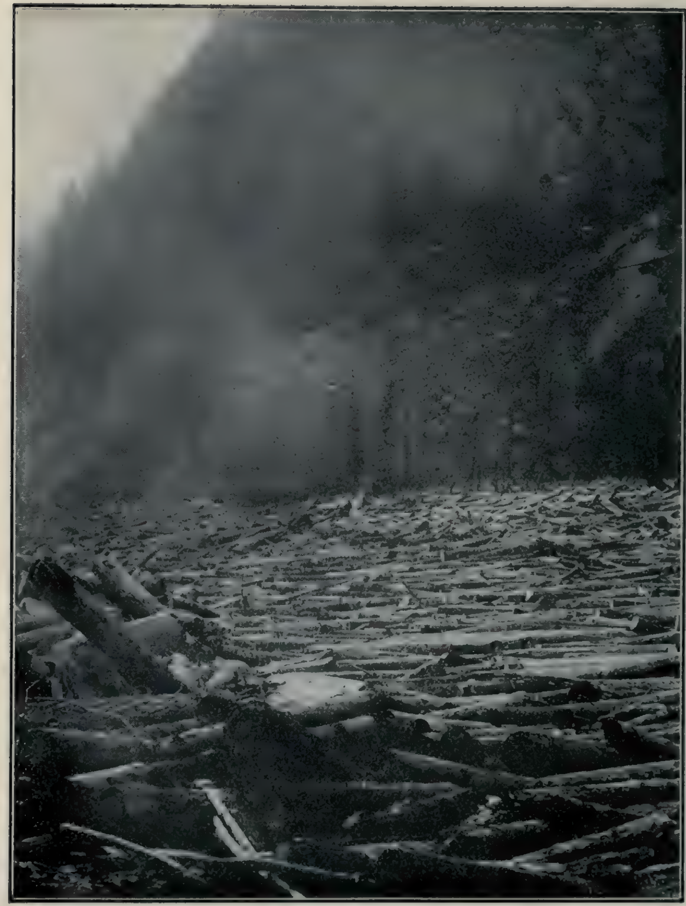
A COLONIAL HOME

even in the most civilized countries, much to do with the style of building adopted. Flat roofs or no roofs at all are preferred in lands where no rain falls, as in parts of Egypt and India; slightly sloping roofs where rain but no snow falls, as instanced by the

Roman and Grecian style of building; and high pitched roofs, to shed the snow, are common in all Northern lands.

The early Britons, history tells us, lived in huts, with walls wattled or woven with wicker-work and plastered with mud, till the more educated Romans who conquered them, taught them to make bricks and tiles and to build strong houses. Roman work was very good and lasting. Though the villas and palaces built by the Romans have long decayed and disappeared, walls still remain as sound as ever around the cities and towns which used to be Roman camps, and still keep their Roman names.

Our own houses are built for health, comfort, and beauty, far beyond the ideas of our forefathers. Think of the many beautiful public buildings and handsome houses of our own day, and contrast them with what we read of ancient dwellings, and even with what is still the custom in many backward countries.



LOG JAM IN THE MOUNTAINS, BY BLACKFOOT RIVER, MONTANA

DRAGGING OUT LOGS WITH SIX-MULE TEAM, DOUGLAS SPRUCE DISTRICT, WASHINGTON

## LUMBER

FIRST of all, we will inquire about the timber and boards which form the frame-work of our houses. To have this inquiry answered, you must come, in imagination, with me to some of the great lumber regions of our land.

The primitive forests of America were of immense extent, and contained a remarkable diversity of trees. In the seventeenth century, the whole of the Eastern and Middle States were covered with dense forests; to-day they are almost all cleared away, and we have to depend on the far Western States and Canada for our supply of building timber.

Fortunately for the United States, the States of Oregon and Washington have the largest unbroken forests on the globe; 57 per cent of the former being timbered and 70 per cent of the latter. On no other tract can the timber be excelled in quantity and quality. About ninety different species of trees and shrubs have been counted in Oregon. These include numerous

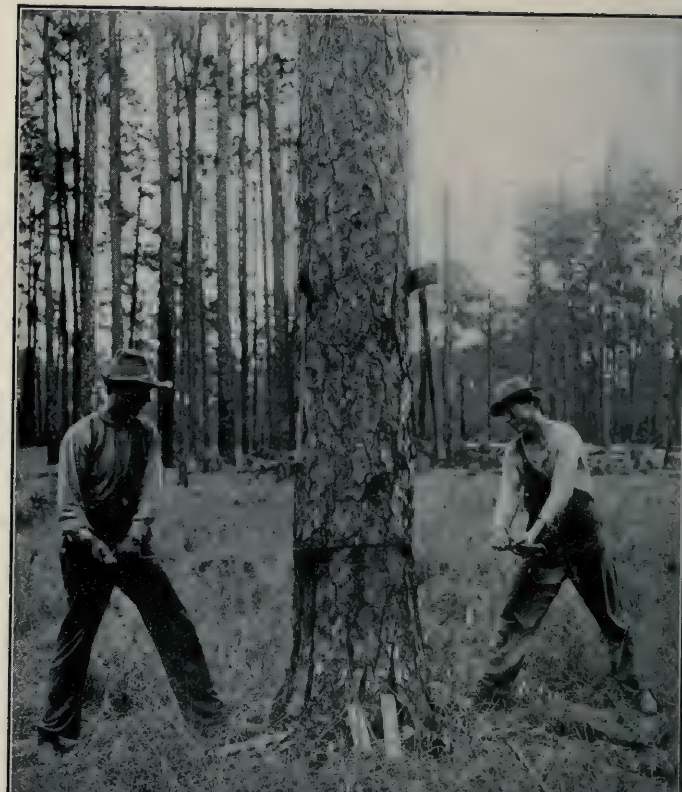
CUTTING REDWOOD TREES IN CALIFORNIA

varieties of the larch, pine, cedar, spruce, hemlock, fir, juniper, cypress, mountain mahogany, cherry, maple, alder, cottonwood, etc. The most valuable are the red, yellow, and silver firs. The latter is especially valuable for its fine-grained, smooth and durable white lumber. The red and yellow firs rival the pine in lightness and the oak in strength and durability. They grow very straight and tall, and often attain a height of three hundred feet. A certain Whatcom County, Washington, fir tree, when cut, measured 465 feet in height and 265 feet to the first limb. The fir trees are known commercially as "Oregon Pine." They have become great favorites with shipbuilders because of their durability. "The winds on every sea are trying the masts of ships innumerable,"

REDWOOD LOGS FROM FOREST TO MILL

says the *Pacific Monthly* — "mighty timbers which once wore, instead of rows of rattling spars, of bellying sails and straining cordage, a crown of beauty greener far than the curling billows of the emerald deep, a crown of feather-like branches that whispered the lore of the Oregon forests."

The large trees, logging camps and saw-mills of these states are a series of surprise to tourists and lumber men from the East. For the handling of



FELLING LONG-LEAF YELLOW PINE TREES, LOUISIANA

Eastern logs some fifteen to eighteen inches in diameter is quite different from managing Oregon and Washington logs from five to ten feet and even larger. The mills of Portland alone cut about one million feet of lumber daily. There are more than five hundred huge saw-mills operating on Puget Sound. Lumber is shipped to all parts of the world. In the last few

CUTTING UP LONG-LEAF PINE, LOUISIANA

years the rafting business between the Columbia and the Golden Gate has reached enormous proportions. There is a big demand for piles and spars at San Francisco, as the teredos destroy a pile every three or four years. (The teredo, also called the ship-worm, is an inhabitant of the water of most harbors, and is very destructive to wood.) There is a great demand for Oregon pine in the Philippines, as it is the only wood so far known that can successfully resist the ravages of the white ant.

LUMBER CAMP IN OPEN WOODS, FLAGSTAFF, ARIZONA

It is said that one who has passed his life on the prairies, and is familiar only with the small trees of that section, cannot comprehend the sublimity and grandeur of these world-famous forests without seeing them. Note the following picture from the *Pacific Monthly:*

"Follow the Siletz, the Coquille or the Trask Rivers in their picturesque windings from source to mouth and you will see along their fern-grown banks, trees

AT DINNER IN LUMBER CAMP, ADIRONDACK MOUNTAINS, NEW YORK

straight as a lance, six feet, yes, often eight or ten feet, in diameter, their smooth trunks unbroken by limbs for a hundred feet, while two hundred feet above your head their branches are thickly interwoven. Here by your side rises in stately dignity a tree that sheltered the forest folk, deer and elk, pheasant and grouse, long before the boats of the Pilgrim Fathers grated keel on the sands by Plymouth Rock. It has survived the ravages of three centuries and it will still be young when you and your children are old."

"SKIDDING" LOGS IN WINTER TIME

Each lumber region has its own methods adapted to the conditions of the country. In the South and East there is still much hand sawing and cutting of trees, while machinery is chiefly relied upon in the far West.

Once a place is selected, camps for the men are made; often tents, or rough wooden shacks, in the West; or log cabins in the Eastern States. The forest echoes with the busy hum of life. Every one is up in the early morning: the cooks fall to work baking bread and slicing salted beef and pork. Breakfast over, the leaders mark the best trees and "logging" begins in earnest. Chopping and sawing go on from morning till night. As the trees fall, one after another, and their branches are cut off, they are hauled together in great brown heaps until sufficient snow has fallen to make the road to the stream hard and even.

LOADING LOGS WITH HOOKING TONGS

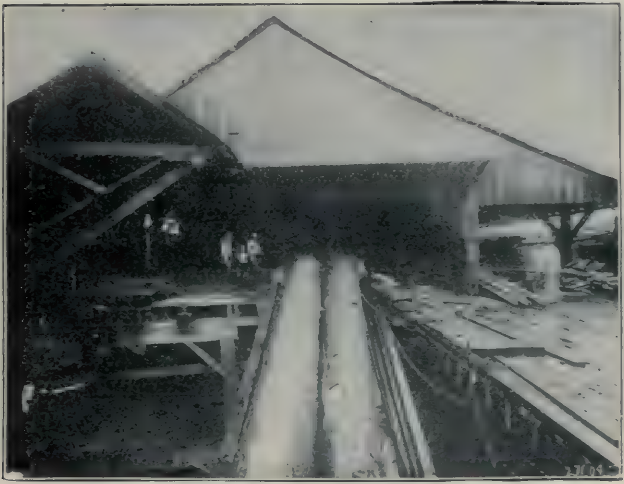
The logs are marked, laid on sleds and take their first land journey. The load, arrived at the stream, now frozen, is toppled over from the sled to the ice. More loads are emptied, and the ice breaks, letting the logs into the water. At last the harvest of timber is piled up for miles along the river not far from the banks.

Here it must rest until the warm spring wind shall come and unfasten its icy chains and set it free. Spring comes at last. The great army of logs has been gathered together and started down stream. It is a long, slow journey. The workers, keeping their slippery positions on the rolling logs, are ready with sharp-

THE GLEN FALLS BOOM, HUDSON RIVER, NEW YORK

pointed poles in hand to correct any rebellious log that may threaten to block the way.

It is an interesting sight to view the transportation of the timber in the early spring — to hold one's breath as the great mass of logs goes slipping and whirling down the running torrent — down, down, to be caught in the whirling rapids, and tossed and whirled in every direction, until a bend in the river brings them into smooth water again. At last comes one bright day in May when the long journey is ended. The logs are dragged upon the river-bank and taken to the great steam saw mills. Into one side they go and come out at the other cut into boards or timbers of any required size or thickness.



HAULING LOG UP INCLINE INTO MILL OF CURTIS LUMBER COMPANY, MILL CITY, OREGON

Frameworks of saws, set close for veneers or wide apart for planks, and moved by steam, cut complete logs of timber at one operation: band-saws, or flexible saws, are made to follow the most delicate tracing of fretwork; and circular saws from an inch to nine feet across, revolving at the rate of a thousand turns a minute, cut the largest "baulks" of timber, as if they were but giant bars of soap.


## MUSIC OF LABOR

The banging of the hammer,
  The whirring of the plane,
The crashing of the busy saw,
  The creaking of the crane,
The ringing of the anvil,
  The grating of the drill,
The clattering of the turning-lathe,
  The whirling of the mill,
The buzzing of the spindle,

The rattling of the loom,
The puffing of the engine,
The fan's continual boom,
The clipping of the tailor's shears,
The driving of the awl —
These sounds of honest industry
I love — I love them all!

The clicking of the magic type,
The earnest talk of men,
The toiling of the giant press,
The scratching of the pen,
The bustling of the market man
As he hies him to the town,
The halloo from the tree-top
As the ripened fruit comes down,
The busy sound of threshers
As they cleave the ripened grain,
The husker's joke and catch of glee
'Neath the moonlight on the plain,
The kind voice of the dairyman,
The shepherd's gentle call —
These sounds of honest industry
I love — I love them all!

LOOKING DOWN INTO THE WEST RUTLAND, VT., QUARRY

The depth ranges from 200 feet at the front edge to 300 feet on the back. The floor space at the bottom of the quarry is 2,000 feet long, extending 400 feet out under the hill and 300 feet back under the railway track.

# MARBLE AND GRANITE

NOW, having seen to what uses the boards and timber are put, let us find out about the stone of which our houses and public buildings are made. Marble and granite are the most beautiful and enduring of all stone, and are the most in demand for prominent buildings and statuary.

Sixty years ago, the land where the West Rutland (Vt.) marble quarries now are, was a barren looking pasture, overgrown with cedars. Here and there among the dark evergreens, gleaming white stones showed themselves above the surface of the ground.

Flocks of sheep gamboled, fed upon the scanty grass, or rested in the shadows there, and nobody knew or even dreamed of the immense wealth which Old Father Time, with rain, and sun, and frost for his tools, had hidden away in the rugged hills.

But a Mr. Barnes, who had noticed the marble rocks and burned some of them to make lime, believed they were good enough to make tomb-stones.

Everybody laughed at the idea, and so cheaply was the land valued that he bought the whole westward slope of the pasture, giving for pay a poor old horse worth about *seventy-five dollars*.

From this small beginning grew the great marble

MARBLE QUARRY, DANBY, VT.
The End of the Cable Road

works of West Rutland. In ten years after the purchase of this land, three quarries were being worked in it.

But all difficulties were not yet overcome. People said that American marble would not keep its purity of color like the imported marbles, so they would not buy them.

But time has proved that the Rutland marble is even better than that of foreign quarries.

Now a line of railroads runs near the quarries, and in the great mills forty-eight gangs of saws, with from eight to forty-eight saws in each gang, run night and day the year round. Beside this there are ten thousand tons or so of marble shipped every year from this to other mills.

In the hillsides are great pits being dug deeper and wider every year; where men and engines work away in all weathers and seasons.

So deep are the pits that the men at the bottom look like so many toiling ants, and up from the depths, made smoky by the breaths of numerous engines, comes the confused sounds of puffing machinery, clinking drills and murmuring voices. All along the edge of the pits are rows of derricks, stretching giant arms and webs of iron guys against the sky.

The blocks of marble have holes drilled in them about six inches apart; into these holes iron wedges are driven, which split off the rock and lift it a little, ready to be seized and hoisted by the derrick.

CABLE ROAD FROM MARBLE QUARRY, DANBY, VT.

The old method of blasting had to be given up because it spoiled many and many a ton of beautiful marble.

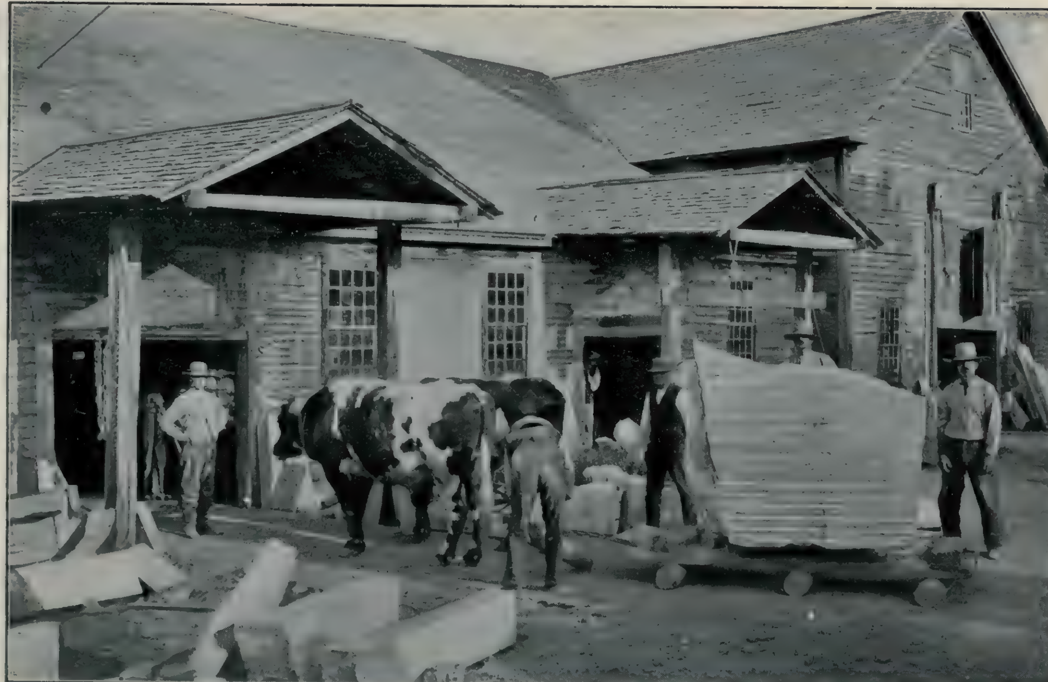
In all large quarries the drilling is done by machines which are moved by steam, and which bite at the rock savagely.

THE HITCHCOCK GRANITE QUARRY, QUINCY, MASS

About the mills and quarries are old-fashioned ox-teams hauling away cart-loads of waste and rubbish, or dragging great blocks of rough marble to the mills.

Passing near the shouting ox-driver, an engine draws its cars up among the great piles of unhewn marble.

I have told you of the busy saws in the mill.—"Saws!" do you ask? "Can they saw marble?"



AN OLD-TIME VERMONT MARBLE MILL

Yes, not with jagged, slender saws, but with great smooth-edged strips of soft iron, worked up and down by a mighty steam engine of three hundred horse power.

On the top of the block to be sawed is piled a heap of sand which is washed into the cuts made by the saw

TOP OF INCLINE, GRANITE RAILWAY QUARRY, QUINCY, MASS.

by the drip of water from overhead, and answers for teeth to the saws.

American quarries furnish as much thin marble for furniture and mantels as do any foreign quarries; for cemetery work and for building we supply an immense amount.

Granite is obtained in much the same way as marble, by drilling and then sawing the blocks; if required smooth, they are ground down with wet sand and emery, and finally polished.

Granite is found in many of the States of the Union. All the New England States produce it and one of them has long been known as the "Granite State." Can you tell me which one? The famous Quincy granite possesses some of the qualities of the red "Scotch granite."

Blocks of granite are used in paving the roadway of the principal streets in our large cities and for sidewalk curbings.

Granite is also used for steps and sills of houses, and frequently for the entire outside of buildings. The Treasury Building at Washington, has columns each of a single stone thirty-one feet high.

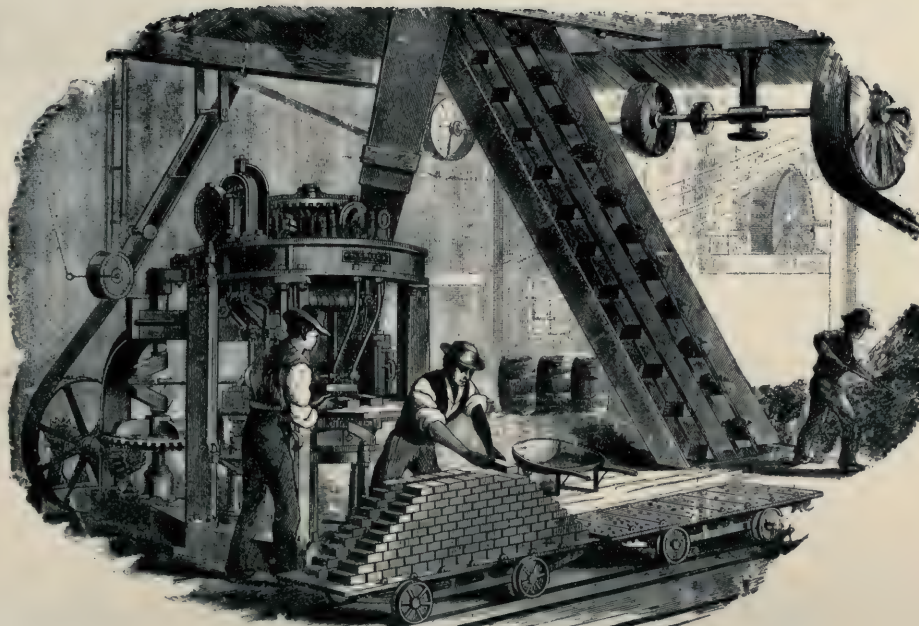
## BRICK-MAKING

WE must not forget to find out about the brick of which we see so much in buildings.

The use of brick dates prior to the time to which our histories reach. In fact, it is said "that the children of Seth, the son of Adam, built two pillars, one of brick and one of stone, and they inscribed upon each of them the discoveries they had made concerning the heavenly bodies, so that their inventions might be preserved to mankind and not lost before they became sufficiently known."

Brick was the building material of the antediluvian days, and it has continued to be building material down to the present time.

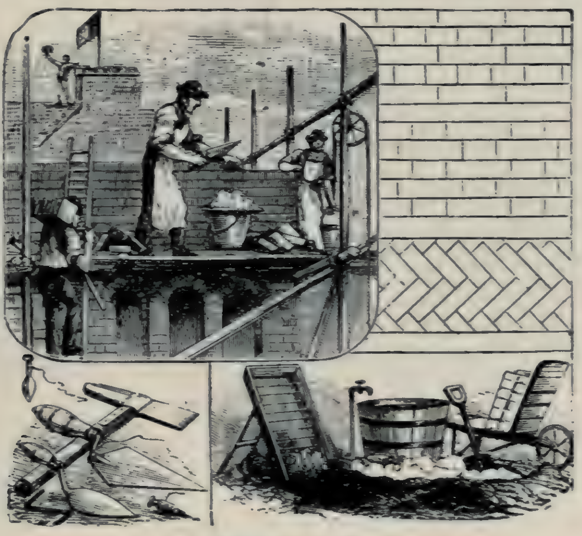
Knowledge of the art of brickmaking has probably at no time become entirely extinct, but after the fourth century, in sympathy with the decline of all other arts and the dying Roman civilization, the knowledge of this art gradually expired, and was lost to western Europe. The art of brickmaking did not revive in England until the thirteenth century; only a few instances of fourteenth-century brickwork occur, and they are toward the close of the style; but in the fifteenth century brickwork became common. Until the first quarter of the seventeenth century the bricks made in England were of many different sizes,



BRICK-MAKING BY MACHINERY

but by Charles I, in 1625, their size was regulated and made nearly uniform. After the great fire of London, in September, 1666, brick was the material universally used in the reconstruction.

In 1784 bricks were subjected to taxation by George III, which burden was not repealed until 1850, and it is from this period that the general improvement



BRICKLAYERS AT WORK

in brickmaking machinery commenced in both the United States and England.

A good authority says, "perhaps there is no process so easy to describe and yet so hard to execute as the making of brick;" and we may well believe it.

Each little detail of digging, kneading, molding and burning the clay seems to be so simple that it would appear that almost anyone could make a good brick if he only had the necessary materials.

But indeed a great deal of experience and much skill is needed to produce a first quality brick.

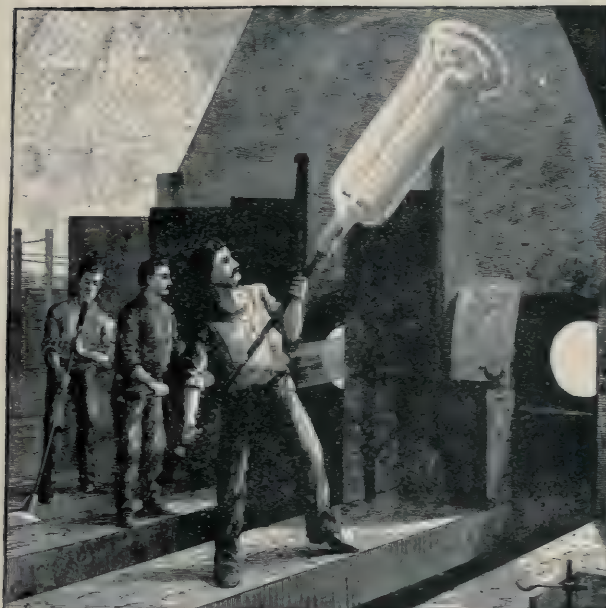
There is a great difference in the nature and quality of the clay found in various localities. It contains much mineral matter, chiefly sand, iron, lime, magnesia and potash.

It is the iron which makes the reddish color, and bricks range in color from yellowish cream to dark red.

Blue bricks are made from the same clay as the red, by some peculiar process of controlling the supply of air in burning, and by carrying the heat slightly further.

Bricks in the United States and Europe are generally red, but some clays produce yellow bricks, as, for example, the *Milwaukee brick*, which is so much used as an ornamental building material. Bricks in China and Japan are of a slaty-blue color.

Philadelphia pressed bricks are in great demand for outer or front walls on account of their perfection. At Haverstraw and other places on the Hudson River, immense quantities of brick are made, and the quality of that produced in New Jersey, Chicago, Peoria and other places is considered excellent. Bricks are found to stand fire better than stone.



## A VISIT TO THE GLASS WORKS

WE all want to know how the glass which forms such a useful and necessary article in our houses, is manufactured, and indeed the process is well worth our attention.

It is very interesting and instructive to watch the making of different articles with which we are familiar, so let us pay a visit to a glass works and spend an hour in seeing them manufacture some of those pretty objects we admire so much, as well as the panes of glass which are put into windows.

We had better begin at the beginning, so let us go into this out-of-door shed, where are such a number of large barrels.

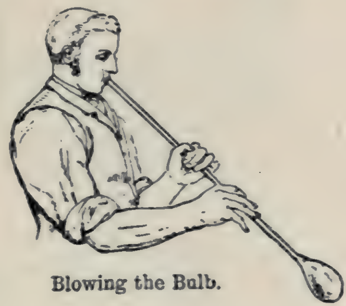
What is this man doing? Mixing what seems like a big pudding in a trough. The principal ingredients of glass are this fine white sand, potash, saltpetre and red lead. They are put together in a crucible — which is a sort of a great jar, with the mouth at the side instead of the top — and placed in a furnace. What a rush of hot air meets us as the man opens a door which leads to these furnaces? Before us towers a dark cone-shaped erection, with openings all around, through which can be seen the intense glow of the molten glass within. Opposite each of these openings is a crucible, and the spaces between are filled up with fuel. All around are men wielding long rods, with what look like globes of fire on the ends.

See the pretty glass bottle. Would you not like to find out how it was made?

There is one just being begun; we will stand here, and see it through. The man we are watching first thrusts his rod, which, by the way, is hollow, into the mouth of a crucible, turns it about for a moment or two, and then withdraws it, loaded at the end with a ball of metal, as the liquid glass is called.

Every trace of sand, lead, and all other ingredients has disappeared, being completely dissolved by the great heat, and pure, clear glass has taken their place. This ball, red-hot, and about as thick as molasses, is rolled for a short time upon a steel plate; then the man blows into it, down the long tube, and we see it swell. He rolls again, and blows again, the globe expanding still more and more, and now the shaping begins, the glowing bulb being all the time twirled

A Crucible.



Blowing the Bulb.

on the top to keep it round, else, being soft, it would lose its form. At intervals it is again put into the mouth of the furnace to heat it up, for if it cools too fast, it becomes too hard to manipulate.

Now we wonder how he will ever get it off the end of the rod without breaking. The man gives the bottle a slight tap, and it is instantly and safely detached.

It would be nice to have one of those bottles to carry away with us, but we should probably break it on the way home, for they are not yet *annealed*, and are extremely brittle. They will have to go into a great oven, which is intensely hot at first, and is allowed to gradually grow cooler. The bottles will not be taken out till it is quite cold. This process, which toughens the glass and makes it durable, occupies considerable time, according to the size and weight of the articles. Then, and not till then, is the glass bottle complete.

## WINDOW GLASS

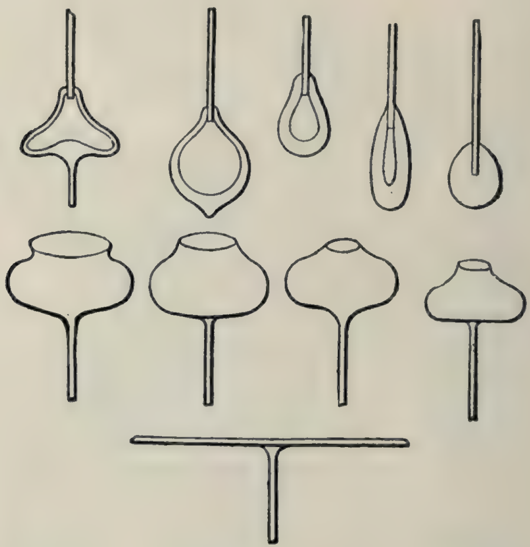
Now let us watch them making the glass which goes into windows. The melted glass having been brought, as we have seen, from a liquid state to the condition in which it may be worked, the gatherer dips the end of his hollow iron rod into the crucible, and collects upon the end a pear-shaped lump of glass.

Resting his rod upon a stand, he turns it gently round, and allows the surface of the lump to cool, to fit it for a second gathering. When he has enough he rolls the glass until it is round and tapering to a point.

FLATTENING THE GLASS

He now blows down the rod, keeping it turning at the same time, and expands the glass into a small globe. Again it is heated, and again blown into a still larger globe. On the next page we see the different stages of blowing and heating from a solid mass to a flattened plate of glass.

All this work must be done with great care, for badly prepared window-glass will lose its transparency on being exposed to the air, therefore the ingredients for making it must be thoroughly tested before being used.



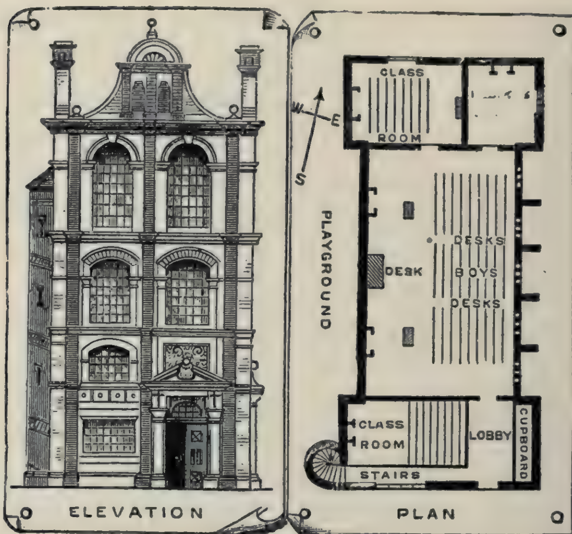
## GLASS TUBES AND CANES

In making glass canes, a mass of glass is gathered and rolled. A flat plate of glass, adhering to a working-rod, is fixed to the end of the mass opposite to where the blow-pipe is attached.

The workman keeps his blow-pipe in his hands, while his assistant holds the working-rod. They now separate, and recede from each other; the greater the distance between them, the greater the length of the glass will be, and the smaller in diameter. Tube is made in the same way as solid cane, with the difference that the mass of glass is blown into and expanded before it is drawn out. Tube or cane is speedily rendered workable by the intense heat of the flame, and can be easily manipulated. The lamp-worker prepares from tube some of the most delicate apparatus used in scientific research, also a variety of goods for domestic and medical purposes. Cane is used in conjunction with tube for ornamental objects.

The first glass factory permanently established in the United States was in Brooklyn, N. Y., about 1754, and the first bottle made at this factory is still preserved among the curiosities of the Long Island Historical Society. Window glass was first manufactured at Pittsburgh about 1795, and from this time the manufacture of glass steadily increased with the growth of the country, until in 1870 glass factories of every kind numbered about 200.

Since that time the business has developed rapidly, and now the value of the glass produced in this country is estimated at $35,000,000, while the factories number about 400.




## HOUSE BUILDING

NOW, having got together our timber, stone and glass, we will proceed to build our house.

First of all, the architect gets his plan ready. Here we have a plan showing how a school is to be laid out; where the class-rooms, lobby and stairs are to go. Then there is the elevation of the school-house, showing how it looks when completed. It is the same, of course, with your dwelling-house. The architect had to draw his plan first, then after the bricks or stones were laid for the foundation, the carpenters came and made the frame, or skeleton, from some of the stronger timbers. Then, for days, the carpenters kept up a banging of boards and a tapping of hammers. Then came the men who nailed with such astonishing speed the rows of laths upon the inside walls.

A carpenter's tool-chest contains many tools, the purpose, shape and making of which have been the reward of long thought and of many minds. It is the great aim of the good apprentice to buy a chest of tools to call his own, and it is his pride, when he becomes a carpenter, to keep them bright and sharp and in the best condition for use.

A carpenter has rules, axes, and an adze, the saw, mallet, hammers, chisels, gouges, augers, planes, pincers, wrenches, a square, a bevel, compasses, a gauge, a level and a plumb-rule.

But who is this fellow in his suit of white in the cellar, stirring vigorously with a hoe a mixture of lime, sand and cow's hair? It is the plasterer's assistant. See the plasterer now dexterously slapping it on to the naked laths, smoothing and polishing it with a grand flourish, calling out "Mortar!" now and then to the strong-limbed man who brings up for him hods full of the "plaster."

Then we have the roofer, who puts on the shingles and makes the roof sound and tight, so that no rain or cold may get in; and the plumber, gas-fitter and electrician, who lay the pipes for water and gas or wires for electricity along the floors and walls. Then

WOOLWORTH BUILDING, NEW YORK CITY
Copyright, 1911, by F. W. Woolworth

come the painters and paper-hangers, who cover the plain boards and plastered walls with pretty designs in painting and wall-paper, and as soon as their work is dry, you may "move in."

HUDSON TERMINAL BUILDING, NEW YORK CITY

The factories and great office buildings of our cities necessitate much more labor in their construction. They require the co-operation of nearly every trade, and give employment to thousands of men.

The Woolworth Building in New York City, of which we give an illustration on the opposite page, is a marvel of architectural and engineering skill and the most exhaustive description on paper will not enable one to appreciate the labor involved.

The building rises 784 feet above the sidewalk. The sub-basement is 38 feet deep and the concrete and steel foundation is 130 feet below the surface. No other building ever reached its total height — practically 915 feet.

Twenty-four thousand tons of steel, 17,000,000 bricks, 43 miles of plumbing, 53,000 pounds of bronze, 12 miles of marble trim, 12 miles of slate trim, 383,000 pounds red lead, 20,000 cubic yards sand, 15,000 cubic yards broken stone, 2,000,000 square feet of hollow tile, and 87 miles of electric wiring are used in the construction.

One and one half acres of exterior window glass and 80,000 electric bulbs supply the light. The building has a total weight of 206,000,000 pounds, 40 acres of floor space, and is 55 stories high. But notwithstanding its great height, it is supposed to be absolutely fireproof, no wood being used in its construction.

And, remember, the men who designed and built this marvelous edifice, and many other wonderful places in our great cities, were once school children the same as you are, and studied the same lessons.

LAUNCHING A FISHING SCHOONER, COAST OF MAINE

## SHIP-BUILDING

THE largest and finest timbers do not go into house-building, as that ship just coming into the harbor can testify.

How strange the contrast between the civilized man and the savage! By joining together some rough boards, the savage makes a raft, floating at the will of the tide without control. He hews down a tree, scoops out the trunk, and forms a rude canoe. The American Indians made their canoes of birch bark.

24,170 tons register — TWIN-SCREW STEAMER "ROTTERDAM" — 37,190 tons displacement

(By courtesy of the Holland-America Line)

Then there was the ancient galley, or trireme, of the Romans, so called because it had three tiers or rows of oars; the ship of ancient Egypt and the gaily decorated argosies of the Greeks. The ships used in the fleet of the Spanish Armada were in some respects a good deal like some of our vessels, except that they were fitted with oars as well as sails.

The war galley of the Greeks originally had a single mast and later two masts, but depended chiefly upon its oars, which were ranged in a single line on each side, and each handled by one rower.

Galleys continued in use in the Mediterranean until late in the seventeenth century, and were often from one hundred to two hundred feet long, with twenty oars to each side, and capable of carrying one thousand to twelve hundred men.

Two of the ships in which the discoverers of the New World started on their voyage were of the kind called caravels. They were not decked over, but were built high at either end, with cabins that looked like houses or castles. The bows were broad and they carried four masts and lateen sails.

Thus we see the gradual transition from the rude canoe of the savage to the iron-clads of war, and the steam vessels of splendid size and comfort which now plough the waves between Europe and America, in as few days as it used to take months.

Ships of to-day are built in different forms, according to the burdens they have to carry.

PLACING A MAST IN A SAILING VESSEL

The place in which the ship is built is called a *slip*. In the middle and leaning down to the water's edge is a row of piles of stout pieces of wood called *blocks*.

It is a strange sight to see the skeleton of one of these huge ships growing into size and shape; every piece must be strong and secure. Generally each part must be fashioned from rough logs, but in some "yards" there are machines so contrived as to saw the timbers at once into shapes having the right curves and twist to fit together.

Perhaps you have seen the keel prepared and laid upon the blocks and have noticed how the frame timbers were lifted and fastened to the places they were to occupy.

The shape and means of making vessels may vary a little, but the end and aim of every ship-builder is to make the whole thing firm, yet light. When the skeleton is at last mounted up in its place it must be clothed or "planked" in as strong and neat a fashion as possible.

At the end farthest from the water is raised the *stem*, which really is the keel carried upward.

The making of port holes, magazines, bunkers, cabins, berths, etc., goes on by degrees during the building of the ship.

A very large mast is built up of pieces called spindles, side trees and other odd names, bound together by iron wedges, driven in hot.

To prevent sea-weed and shell-fish from collecting

A HOUSE-BOAT

on the bottom, ships are often sheathed with thin sheets of copper, which sheds them off.

Iron is now considered a better material for building ships than wood. One reason for this is that the same

VIEW OF BOW
Steamship "Rotterdam," Holland-America Line

strength may be obtained with less weight. Another that the iron plates can be bent to any curve, thus avoiding the combinations necessary for strength in a wooden vessel.

The first process in iron ship-building is the laying off the lines of the vessel full size upon the floor of a large room, called the mold-loft. Rough wooden patterns, called templets, are then made of the sections of the ship, one templet to every section.

The ship is made ready much the same as for a wooden ship. The keel is generally of flat bar-iron, sometimes in several thicknesses, the different lengths being joined at the ends, and riveted together. All the iron work of a ship is fastened together by rivets.

In an iron ship the ribs, called frames, are always made of angle-iron. This is a rolled or wrought bar of iron in the form of an angle. The frames are bent, while red-hot, upon a large flat cast-iron plate, into the proper curve according to the plan, and then set up in place upon the keel.

The floors of the decks, which are made of narrow iron plates running crosswise of the ship, are bolted solidly to the frames.

After the skeleton frame of the floors, and the beams, which support the deck, are in place, the outside sheathing plates are put on. Each plate is of the exact size and shape called for in the model.

Iron ships are always divided into a number of compartments by crosswise partitions, called bulkheads. These bulkheads have water-tight doors, and should a leak occur in one part, the doors of the other parts may be quickly shut, thus keeping the water confined to the part where the leak occurred.

Steel is now coming into favor in the construction of ships. It possesses much greater strength than iron, so that the various parts of a steel ship may be made much lighter for the same strain than an iron one.

LEAVING THE WAYS
Launching of the Steamship "Rotterdam," Holland-America Line

The great ship building yards at Chester, Pa., Philadelphia, Baltimore, San Francisco, and at Buffalo, on the lake, are turning out iron and steel ships.

The steamship shown on page 156 is built of steel, and is among the largest in the world.

VIEW OF HOMER LAUGHLIN CHINA WORKS

# POTTERY

OTHER necessary articles in furnishing our house are the cups and plates and dishes which we need for our use, besides vases and ornaments which are so pretty to look at and for holding flowers, etc.

These are all made in a pottery, which it will be necessary for us to visit, in order to gain some idea of the way in which these articles are made.

Pottery-making is one of the oldest of the world's industries. The people in the earliest days of Egypt, Babylonia and Assyria sat at the "potter's wheel" and rolled, and dabbed, and shaped the yielding clay.

Dr. Livingstone, traveling in Africa, found that pottery-making had been known to the African people from the remotest days; for broken bits of crockery were found hidden away among the oldest fossil bones discovered in their country.

The most important manufactories of the United States are in West Virginia, Ohio, New Jersey, New York and Illinois.

Let us pay a visit to the celebrated Homer Laughlin China Works at Newell, West Virginia, where is located the greatest china factory in the world.

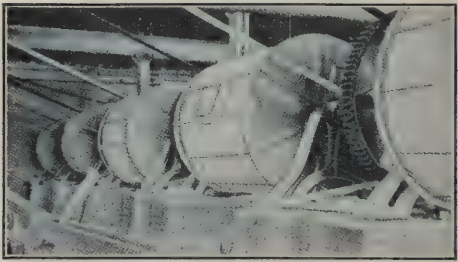
Some idea of the extent of this factory may be gathered from the fact that it contains more than fifteen acres of floor space.

MILL FOR PULVERIZING MATERIALS

This one concern produces each year forty-five million pieces of china-ware, or enough in two years to supply one piece of china to every man, woman and child in the United States.

Instead of the modest two-kiln plant with which this American firm started in 1871, there are now in operation sixty-two general ware kilns and forty-eight decorating kilns — a total of one hundred and ten kilns.

Many different kinds of raw materials are required to produce the clay from which china is formed, and these ingredients come from widely separated localities. Clays from Florida, North Carolina, Cornwall and Devon. Flint from Illinois and Pennsylvania. Boracic acid from the Mohave Desert and Tuscany. Cobalt from Ontario and Saxony. Feldspar from Maine. All these and more must enter into the making of every piece of china.



GRINDERS FOR REDUCING GLAZING MATERIALS

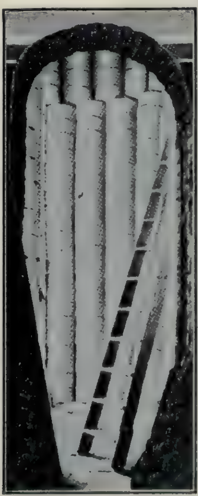
These materials are reduced to fine powder and stored in huge bins. Between these bins, on a track provided for the purpose, the workmen push a car which bears a great box. Under this box is a scale for weighing the exact amount of each ingredient as it is put in, for too much of one kind of clay or too little of another would seriously impair the quality of the finished china. From bin to bin this car goes, gathering up so many pounds of this material and so many pounds of that, until its load is complete. Then it is dumped into one of the great tanks called "blungers," where big electrically driven paddles mix it with water until it has the consistency of thick cream. From the blungers this liquid mass passes into another and still larger tank, called a "rough agitator," and is there kept constantly in motion until it is released to run in a steady stream over the "sifters."

These sifters are vibrating tables of finest silk lawn,

MOLDING DISHES
The racks to the left are full of molds on which the clay is drying

very much like that used for bolting flour at the mills. The material for china making strains through the silk, while the refuse, including all foreign matter, little lumps, etc., runs into a waste trough and is thrown away. From the sifters the liquid passes through a square box-like chute, in which are placed a number of large horseshoe magnets, which attract to themselves and hold any particles of harmful minerals which may be in the mixture. After leaving the magnets the fluid is free from impurities, and is discharged into another huge tank called the "smooth agitator." While the fluid is in this tank a number of paddles keep it constantly in motion.

From the smooth agitator the mixture is forced under high pressure into a press where a peculiar arrangement of steel chambers packed with heavy canvas allows the water to escape, filtered pure and clear, but retains the clay in discs or leaves weighing about thirty pounds each. From the presses this damp clay is taken out to the "pug mills," where it is all ground up together, reduced to a uniform consistency, and cut into blocks of convenient size. It is now ready to use. Automatic elevators carry it to the workmen upstairs.



INTERIOR OF A KILN
Showing how the "saggers" are packed for firing

The exact process of handling the clay differs with articles of different shapes. Some are molded by hand in plaster of paris molds of proper shape, while others are formed by machine. To make a plate, for example, the workman takes a lump of clay as large as a teacup. He lays this on a flat stone, and with a large, round, flat weight strikes it a blow which flattens the material out until it resembles dough rolled out for cake or biscuits, only instead of being white or yellow it is of a dark gray color. A hard, smooth mold exactly the size and shape of the inside of the plate is at hand. Over this the workman claps the flat piece of damp clay. Then the mold is passed on to another workman, who stands before a rapidly revolving pedestal, commonly known as the potter's wheel. On this wheel he places the mold and its layer of clay. He then pulls

TAKING DISHES FROM THE KILNS

down a lever to which is attached a steel scraper. As the plate rapidly revolves, this scraper cuts away the surplus clay, and gives to the back of the plate its proper form. The plate, still in its mold, is placed on a long board, together with a number of others, and shoved into a rack to dry. One workman with two helpers will make 2400 plates per day. It is fascinating to watch the molders' deft hands at work swiftly changing a mass of clay into perfectly formed dishes.

When the clay is sufficiently dry, the plate is taken from its mold, the edge smoothed and rounded, and any minor defects remedied. It is then placed in an oval shaped clay receptacle called a "sagger," together with about two dozen of its fellows, packed in fine sand, and placed in one of the furnaces or kilns. Each kiln will contain on an average two thousand saggers. When the kiln is full the doorway is closed and plastered with clay, the fires started, and the

WHERE PLATES ARE DIPPED IN THE GLAZING SOLUTION

dishes subjected to terrific heat for a period of forty-eight hours.

When the plate is taken from the kiln after the first baking, it is pure white, but of dull, velvety texture and is known as bisque ware.

In order to give it a smooth, high finish, the plate is next dipped into a solution of white lead, borax and silica, dried, placed in a kiln and again baked. When it is taken out for the second time it has acquired that beautiful glaze which so delights the eye. In this condition it is known as "plain white ware," and is finished, unless some decoration is to be added.

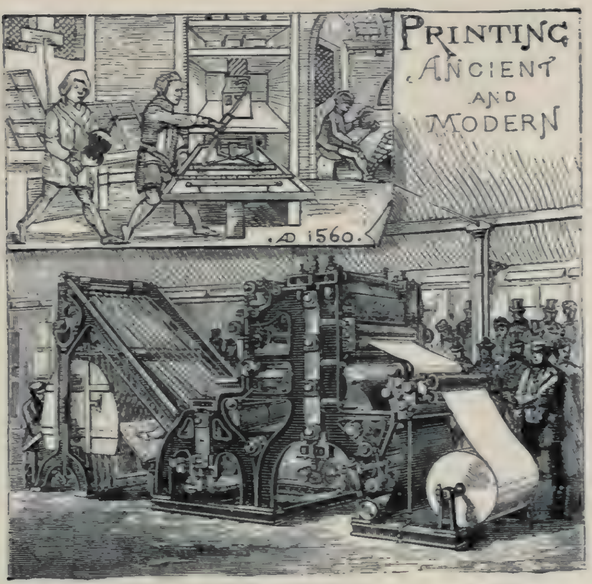
Most people are surprised to learn that the greater part of the gold which adorns dishes is put on by a simple rubber stamp. Two preparations of gold are used: one, a commercial solution called "liquid bright gold;" the other, very expensive, is simply gold bullion melted down with acids to the right consistency.

A SECTION OF THE DECORATING DEPARTMENT
More than four hundred decorators are employed at the Homer Laughlin Works.

Decorating in colors is now done almost exclusively by decalcomania art transfers. These are made principally in Europe.

After the gold and colors are applied, the china must again go through the oven's heat for a period of twelve hours. Then the piece, finished at last, is ready to grace your table. The dull gray clay has become beautifully finished china, which will delight alike the housekeeper and her guests.

SORTING THE RAGS
(Courtesy of Champion Coated Paper Co., Hamilton, Ohio)




NEWSPAPER PRESS

## PAPER AND PRINTING

AND now that we have learned of the building and furnishing of the home, let us inquire into the further necessary furnishing of the library or reading room.

The Athenians of old, who spent their time in nothing else but either to tell or hear some new thing, could not have been more eager for news than our own age. We are eager to learn the affairs of every day in the State and in the Nation. We like to know what is going on abroad as well as at home, and every boy and girl in the United States, with the advantages now offered on every hand, become well-informed, intelligent men and women, "pioneers" in the march of their race towards a still higher civilization.

But before we make a journey to that wonderland prepared for us by man's genius and intelligence, the modern newspaper, let us study a little of the progress


of printing and book-making from ancient times up to the present day.

In olden days, hundreds of years before you and I were born, there were no schools for boys and girls, where they might learn of things that were strange and unfamiliar to them. In the days of ancient Europe, the young people gathered around some fine old tree, and listened to words of wisdom from the white-haired men, whom they were taught to respect — who spoke to them of love for their country, as your teachers now speak to you of yours. By listening to them, they committed to memory an immense amount of tradition in matters of history, poetry and religion.

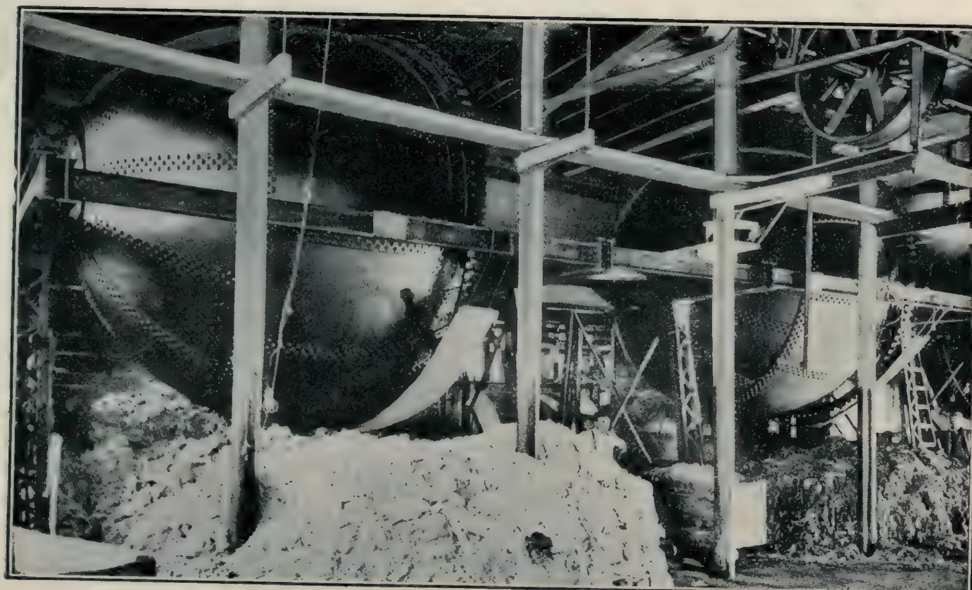
There were no books in those days, and people must have greatly felt the need of some mode of fixing facts without trusting to the varying and fading powers of memory.

Later on, picture-writing, or the expressions of ideas by drawings of objects, appears to have been the stepping-stone to the letters now used in writing, and even in our day the Chinese still employ single signs for whole words.

Such, too, were the sacred engravings or hieroglyphics of Egypt, the arrow-head writings of Nineveh and Babylon, the picture records of the Aztecs and of the Incas, who ruled Mexico and Peru before the days of Cortes and Pizarro, and of the Indians who once occupied our own country. Hermes, who lived two thousand years before Christ, has the credit of inventing hieroglyphics, but it is more than likely that some of the clay tablets at Nineveh are older than the oldest inscriptions of Egypt.

These earliest forms of writing were at first only impressed in soft clay, and baked in the sun; but they were afterwards cut in stone or metal.

The next step in the advancement of knowledge was



LARGE STEAM ROTARY BOILERS WHERE THE RAGS ARE COOKED
(Courtesy of Champion Coated Paper Co., Hamilton, Ohio)

the preparing of *papyrus* in a form for writing, and it is to these records, which they folded in the bandages of their embalmed dead bodies, that we owe much of our knowledge of the country, and the manners and customs of the inhabitants. How little we think of the great benefit conferred by the genius of


the inventor of this important preparation! His name is utterly lost, but his intelligence served to link with a chain of true history the events of the past and present of the human race.

Papyrus, from which we derive the term paper, was prepared from the pith of a rush or reed, growing on the banks of the Nile.

The light cellular pith was cut with a sharp knife in a spiral, just as cork-cutters cut cork, and the Chinese their so-called rice-paper. When unfolded, as we unfold a roll of paper or a bale of cloth, it spread out into sheets which were pressed flat, several, one upon another, cemented by their own gum, as we make cardboard of layers of thin paper and paste. These sheets of papyrus were written upon with a calamus or small reed, and with ink made of ivory black and resin. Though so fragile a substance, many papyrus records have outlasted the obelisks of Egypt and the baked tablets of Nineveh.

Rock inscriptions were common long after papyrus had been applied to writing. Moses wrote the commandments on two tablets of stone; a fact pointing out that the Hebrews had learned the art of writing during their sojourn in Egypt, an art which they did not possess when they entered that country.

The Greeks and Romans used tablets of wax, written upon with a style, or metal point, even while importing papyrus from Egypt.

In the last centuries, before the birth of Christ, parchment, prepared from the skin of the goat, and vellum, from the skin of the lamb and calf, began to take the place of papyrus. The Persians, however, are stated to have written their annals on vellum at a much earlier date. Many of the oldest and most valued manuscripts are of this durable substance.

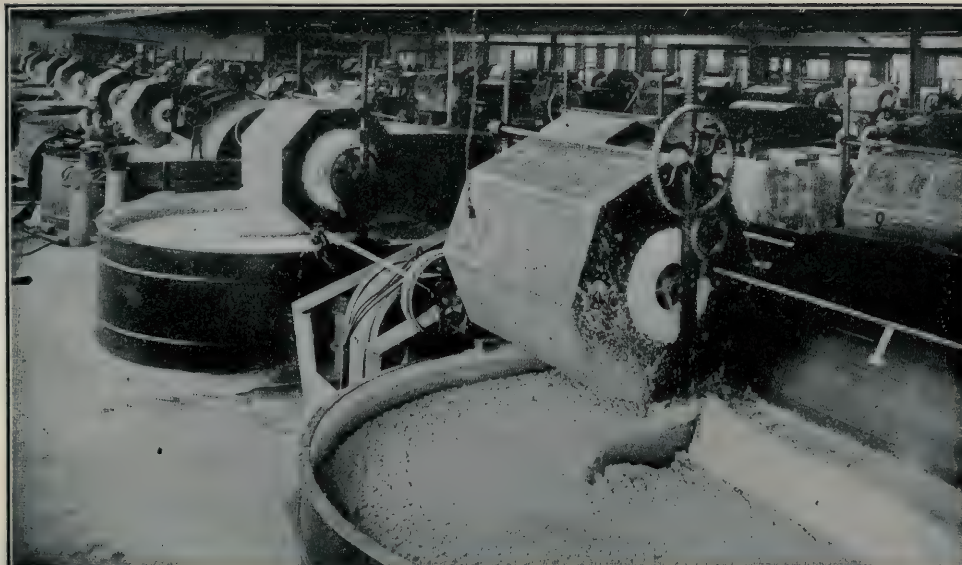
The writers and copyists of the Dark Ages were monks and priests, those patient, self-denying men, who, to keep the lamp of knowledge burning, covered myriads of skins with their learning in the most perfect and patient penmanship and illuminated writing.

It is difficult to conceive of a time when man could not transmit to future years a record in permanent form; but as the process of evolution furnishes a means of fulfilling growing requirements, there has developed from the crude methods of our far-away ancestors, the paper-making industry, which to-day is of so vital importance in the life of the race.

A writer who recently visited the great paper mills of Massachusetts and Ohio thus describes the modern methods of making a high-grade bond or book paper at the mills of the Hampshire Paper Company at South Hadley, Mass.

In a high-grade bond paper, the raw material consists of new rags. These are gathered from various mills and factories, shirt and linen mills furnishing the greater part.

The rags are first brought into the sorting-room, where every piece is carefully examined by skilled women workers, who separate them and take out any dirt or foreign substance. The rags are then cut into shreds of uniform size, and pass into the washing engine. Here the rags are further pulled apart and thoroughly cleansed by the washing process. As they are being driven about by a washing machine, a stream of clear water is constantly flowing in at the top, while



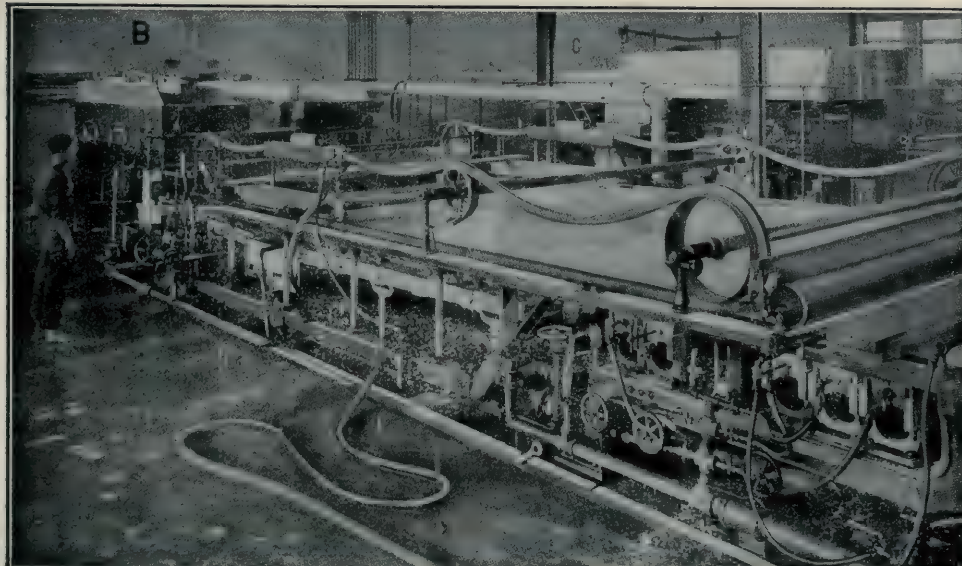
PARTIAL VIEW OF ONE OF THE BEATER-ROOMS
(Courtesy of Champion Coated Paper Co., Hamilton, Ohio)

the starchy water is drawn off by means of an ingenious mechanism.

All vestiges of dirt are now removed. A most thorough kneading process is the next step, the clippings being driven again and again under the wash roll, where they are pulled apart until no sign of the original fabric remains. After some hours, the shreds have become so fine that the substance resembles a mass of cotton. It is at this point that chemicals are introduced for bleaching purposes, to remove from the fibres any color which may yet remain.

The material in the tub is then emptied into the drainer, where, after several days' continuous draining, it is ready for the beating engine. Here it receives its last washing, and the bleaching chemical is removed. The shredding process is continued for a considerable number of hours, until the fibres become the proper length. If the paper is to be colored, the coloring dye is added at this stage, and is so thoroughly combined with the pulpy mass that every fibre has the proper tint.

We are now ready for the paper machine. This wonderful invention, which has revolutionized the process of paper making, has remained much the same for all practical purposes as when first invented. It begins with an endless sheet of wire cloth, upon which is delivered the pulp. The flow of this gruel-like substance is minutely regulated according to the thickness of paper desired. Belts of rubber run along




SHOWING THE PAPER ENTERING THE MACHINE IN LIQUID FORM
(Almost 99 44-100 pure water)
(Courtesy of Champion Coated Paper Co., Hamilton, Ohio)

the side of the wire sheet in order to keep the milky substance from running off the wire. The desired width of paper, of course, determines the distance between these rubber belts. As this wire carries the substance along, a jerky, shaking process is imparted to the wire sheet, which causes the innumerable fibres to weave together, and thus is obtained, in soft and liquid form, a sheet of paper.

While the pulp is yet in a flabby condition, the "water-mark" is given to the paper by a revolving wire-cloth cylinder, upon which are fastened raised wire letters. This type causes the fibres to separate, leaving the paper thinner in the places where the fibres have been displaced. Thus, we find a seeming transparency in the paper where the water-mark appears.

The damp paper is now carried by a roll of woolen felt over hollow rollers called "dryers," heated by steam to the required temperature. The number of these "dryers" around which the wet paper passes varies according to the thickness to be obtained, a heavy paper requiring a larger number of dryers than a lighter paper.

After the paper becomes perfectly dry, it is still carried on rollers to the sizing tub, where it is given a bath of hot sizing. This sizing is simply glue made from clippings from the hides of animals, its principal use being to render ink-proof the surface of the paper, so that ink will not spread by being absorbed, as in blotting paper.

In the finishing-room, the sheets first pass through a machine called the "plater," where every wrinkle is evenly ironed out, and the desired finish obtained. The paper is then sorted by skilled women, and the sheets which are in any way imperfect, eliminated. The paper is counted into reams of five hundred sheets, the edges trimmed and the packages sealed.

It is now ready to be sold, and to go forth on its mission of usefulness. The bundle of rags has been transformed into a perfect sheet, ready to carry a message of success or failure, of joy or sorrow, or to fulfil its mission in the innumerable transactions which identify paper with every phase of life.

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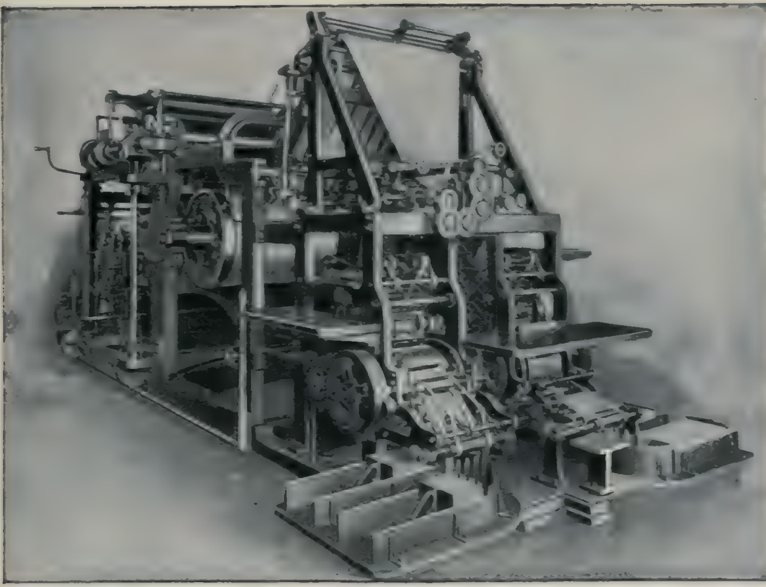
**The World's Paper.** The world's daily print paper output and consumption is as follows:

| | Output Tons | Consumption Tons | Exports Tons | Imports Tons |
|---|---|---|---|---|
| United States | 5000 | 5000 | 1000 | 1000 |
| Canada | 1500 | 400 | 1100 | .... |
| Germany | 1100 | 800 | 300 | .... |
| England | 800 | 1100 | .... | 300 |
| France | 700 | 700 | .... | .... |
| Sweden | 300 | 200 | 100 | .... |
| Norway | 300 | 200 | 100 | .... |
| Russia | 150 | 150 | .... | .... |
| Japan | 100 | 100 | .... | .... |
| China | 25 | 25 | .... | .... |
| Australia | .... | 75 | .... | 75 |
| Belgium & Holland | .... | 50 | .... | 50 |
| Balkan States and Turkey | .... | 25 | .... | 25 |

South America and Africa and any country not mentioned are supplied chiefly by the United States, Canada and Germany.



BOOK ROTARY PERFECTING PRESS

## PRINTING

Block printing was the earliest mode of taking impressions on paper. A design cut in wood was evenly covered with color, whereby the printer could transfer it by hand-pressure on to a sheet. This art was a great step in advance of the slow plan of copying books with the pen. It was introduced about the middle of the fifteenth century as a new discovery, though the Chinese — we might almost say, of course — had printed for ages by this means, and still continue to do so. You can see examples of their printing in the paper, printed only on one side, which covers every chest of tea.

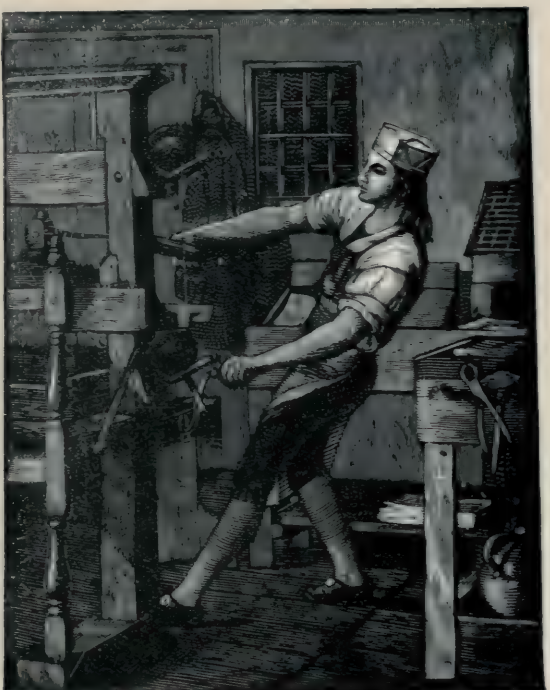
A German named Gutenberg, about the year 1440 cut metal letters or types by hand, and printed the Mazarin Bible, the first edition of the Scriptures, in movable type. William Caxton was the first letter-press printer in England, and his earliest work was "The Game and Play of Chesse," printed about the year 1470.

JOHANN GUTENBERG CASTING FIRST INDIVIDUAL TYPE

The types up to this date, and to the close of the century, were all in Gothic character, or Black-letter, still printed from in Germany. Roman letters were brought in in 1500. Cranmer's Bible, in these simple characters, and in native English, appeared in 1539.

The first printing press used in North America was put up in Cambridge, Mass., about the year 1638.

You all remember reading of how our great and wise Benjamin Franklin longed, when he was a boy, to be a printer, and of his early struggle to own a press of his own. Here we have a picture of him working away at his press, and can see how proud and happy he looks.



FRANKLIN WORKING AS A PRINTER

For a long time after the introduction of printing, the printers themselves cast the types they used, and printed and bound the works executed in their own establishments, and it was not till about 1735 that the first type-foundry was established in Pennsylvania, at

Germantown. There are now many type-foundries in the United States.

In every complete assortment of printing types, there are about two hundred and fifty pieces, counting the capitals and small capitals, italics, figures, punctuation and reference marks, etc., and plenty of these different pieces must be kept for each different style of type.

There are hundreds of kinds, too, for ornamental work.

Besides the letters and other characters, there are the spaces, made in several sizes, to be used between the words. There are also "quadrates," or "quads," which are used for "blanking out" short lines, and in other places where blank space is required.

Types have little nicks low down on the body of the metal, so that the compositor, the man who sets them up at the printing-office, can readily see how to place them right side up. A small groove is taken out of the bottom, so that each type, when arranged in pages or columns, will stand on its "feet."

Think how exactly each of these little pieces must measure and "fit."

A famous foundry for making type is that of the American Type Founders Company. The proprietors of this foundry will be pleased, at any time, to show teachers and pupils the various processes of type-making.

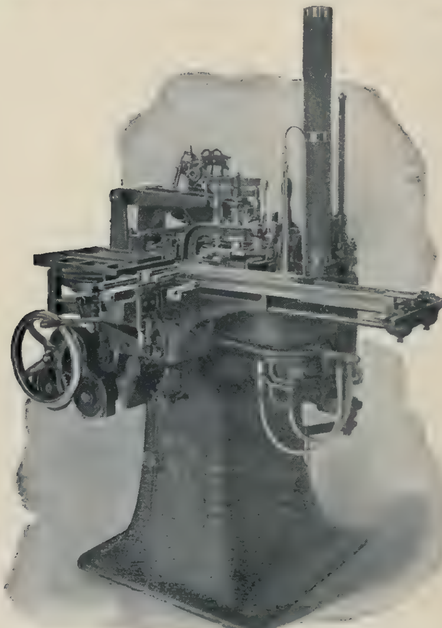
Each of the type-casting machines takes up about as much room as does the sewing machine in your home.

But these type-making machines have to be made themselves: this is done in another department and the matrices and molds fastened into their places. It

KEYBOARD—THE LANSTON MONOTYPE

takes a good many pieces to cast a mold for a type no larger than a pin-head, and these must be made as true and exact as the works of a fine watch.

After the printer has obtained type from the foundry, it is sent to the composing-room, where it is "laid" in cases. These cases are of wood, divided into compartments, one for each letter, character, and space used in printing. The small letters go into the "lower case," and the capitals into the "upper" or "cap" case. From these cases, the compositor, with the copy on the "cap case" in front of him, sets the type up in a composing-stick. This composing-stick is of metal and can be adjusted to different widths.



CASTING-MACHINE — THE LANSTON MONOTYPE

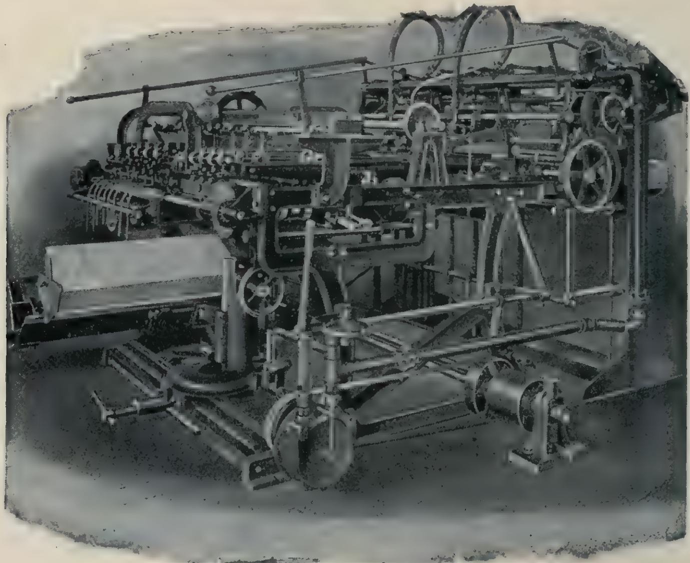
If you were to ask the compositor why he took some of the spaces out of the line of type he had just set, and put in others, he would tell you that he wished to make the line of type of the proper tightness in the stick, or "justify" it.

Thus line after line is set and "justified," until the stick is full. The lines of type are then placed on the galley, a shallow, oblong metal tray, with rims at the top and sides. When ready, the galley of type is "locked up"; that is, secured by wooden sticks down the side, held in position by small wooden blocks. Then it is inked, and a proof taken, which is read by the proof-reader, after which the mistakes are corrected by the compositor.

But very few of the books, magazines, and newspapers you read nowadays are printed from types set in this way. During the latter part of the nineteenth century wonderful machines were invented for the making and setting of type. One of these machines — the Lanston Monotype — has been in use since 1899. It consists of two parts — a keyboard and a casting machine — which are shown in our illustrations.

When the keyboard operator depresses the keys, perforations are made in a ribbon of paper. This ribbon, when placed upon the casting-machine, controls the mechanism whereby the matrices, to which the perforations correspond, are brought in contact with the mold. Through this mold the molten type-metal is pumped.

The type comes automatically from the casting-machine onto a galley, in lines "justified" as evenly as those set by hand. Each character being cast on a separate body, corrections and alterations are made as readily as with hand-set type.



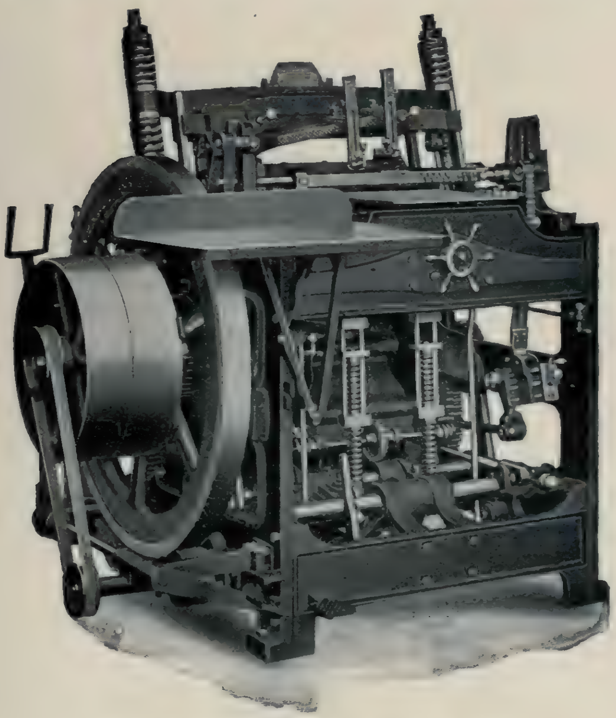
CHAMBERS FOLDER, WITH AUTOMATIC FEEDER ATTACHED

## BOOK-BINDING

AFTER printing, the book sheets are folded into what are known as "signatures." Each "signature" contains sometimes eight, sometimes sixteen, and sometimes thirty-two pages.

This folding is done by machines. Most of the folding machines now in use have an attachment, called an automatic feeder, by means of which the sheets are fed into the machine.

After the folding comes the gathering, or putting together of the different signatures which make up a book. Now, because the sheets were printed and folded so rapidly, they are not pressed firmly together as they appear in your nice, new school nooks. To

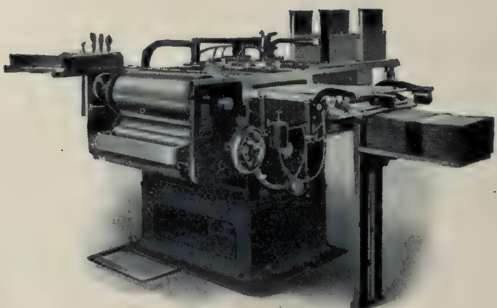


THE CRAWLEY ROUNDING AND BACKING MACHINE

make them lie perfectly flat, they are put into a "smasher," which squeezes them so tightly that the book becomes almost as hard as a board, and only an outside leaf in a pile of many thousands will be loose.

Now the signatures of each book must be fastened together. Sometimes this is done by a book-sewing machine, and is called sewed work; sometimes on a thread-stitcher, when it is known as thread-stitched or side-stitched work.

After sewing, the edges have to be trimmed in a cutter, and the back is rounded by another machine.



THE SMYTH CASE-MAKING MACHINE FOR BOOK COVERS

Then the covers! How wide your eyes would open with astonishment could you see how deftly they are turned out by the machines on which they are made. The making of the covers is called case-making by book-binders, and the machines case-making machines. A particular kind of cloth made for the purpose is used for all "cloth" bindings. It is cut enough larger than the two sides and back of the book to admit of its being turned over at the edges. The foundation is of a kind of pasteboard known as binder's board.

The stamping or lettering in gold on the covers is done with a heated stamp. The embossing or press-ing the design upon the covers, plain or with ink, is done with a powerful press.

Even the putting of the book in its cover is done by machinery. This is called "casing-in," and the machine is known as a casing-in machine.

If we look at a well-printed book, we see that the type on one side of a page is exactly even, line upon line, with the type on the other side. This is called accurate or true register. It prevents the ink from showing through the paper and blurring the pages.

When we compare the first rude attempts at printing, and the first books printed, Chinese fashion, on one side only, because of the poorness of the paper, the thinness of the ink, and the heaviness of the blocks that made the impression — when we compare these with the books of to-day, then, and then only, can we realize the course and strides of intelligence in this direction.

Books upon books are issued, superbly bound, and illustrated with engravings in the highest style of art. Railway stations, at home and abroad, are furnished with book-stalls, to spread the earliest daily intelligence among high and low, and to while away the traveler's hours.

WORLD BUILDING, NEW YORK.

HERALD BUILDING, NEW YORK CITY

## A NEWSPAPER IN THE MAKING

THE publication of newspapers and magazines is one of the features of the age in which we live. Newspapers flourish everywhere throughout the United States, and as there are more than 12,000 so-called country papers published and over 2300 daily papers, almost everyone is more or less familiar with some kind of such a periodical. A modern newspaper in the making occupies the skill and energy of a very large number of both men and women. It wields a tremendous influence not only in local affairs, but wherever its patrons and subscribers may be. Many newspaper plants are, accordingly, exceedingly valuable properties. John L. Given states in his book, "Making a Newspaper," that there are in New York newspapers which could not be bought for ten million dollars.

The province of a newspaper is, of course, to print the news, but this is by no means so simple a process as it might at first appear. The news must be gathered intelligently. It must be cast in readable form. It must be printed and then distributed. The complexity of all this may best be understood by an actual visit to a great newspaper office. Some newspaper owners welcome visitors and make their plant a kind of show place, into the various departments of which visitors are personally conducted. To the chance visitor, even the best regulated newspaper office seems, at least at first sight, to be full of confusion. In this respect as in most others, however, appearances are deceitful, for organization is the keynote in every newspaper office, here, there and everywhere.

The organization of a newspaper is patterned somewhat after the fashion of an army. One editor corresponds as nearly as may be to the Commander-in-chief; others, in a similar way, may be likened to generals of divisions; under these are still others representing petty officers, and finally a host of privates.

First in importance is, of course, the owner of the newspaper. In the business department the business manager is supreme, as he has charge of the finances. He it is who is sometimes charged with directing editorial policy in spite of the divorce that is popularly supposed to exist between the business and editorial ends of every paper. Under the business manager is the advertising manager, who sells the paper's adver-

BUSINESS OFFICE, NEW YORK HERALD

tising space. Then there is the circulation manager, whose business it is to see that the paper has readers, or if it has not, to attract them to it by means of premiums or otherwise, and who supervises the distribution of the printed papers to the news companies and newsdealers, through whom they reach the public. The cashier and other assistants make up the force in the business department.

In the editorial department the editor-in-chief is next in importance to the owner. He directs the policy of the paper and writes or approves the editorials. The managing editor, whose authority is next highest, has charge of the news, sees to the gathering of it, and under his direction it is prepared for publi-

CITY ROOM, EDITORIAL DEPARTMENT, NEW YORK WORLD

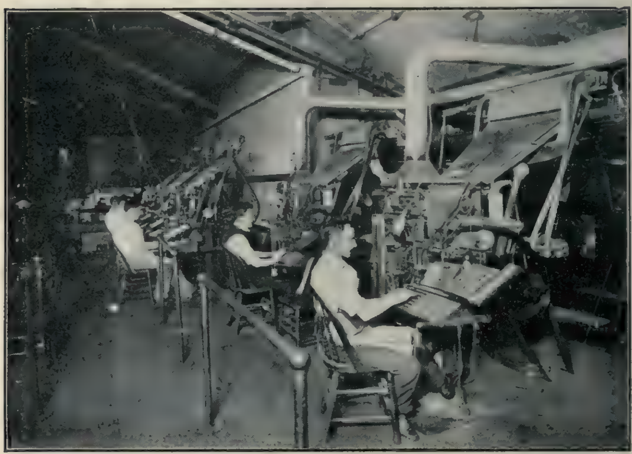
cation. Subordinate to the managing editor are the city editor and the night city editor, for handling the local news; the telegraph editor, who has charge of all the news coming from outside the city; the art editor, in charge of illustrations, decorations, typographical effects and of cartoons; the exchange editor, who reads and clips the out-of-town papers; the music, art and dramatic critics, the financial, real estate, sporting and society editors, and the editor of the Sunday supplement. There are, in addition to the editors named, copy-readers who edit the articles or stories sent in by correspondents to reporters and who write headings for them.

In a newspaper's mechanical department there are three heads: the foreman of the composing room, the

VIEW OF COMPOSING ROOM, NEW YORK WORLD

foreman of the stereotypers, and the superintendent of the press room.

When the news is gathered under the inspiration and direction of the men just named, and made into copy, it then goes to what is called the composing room to be put in type. In the preceding chapter you learned of the change from typesetting by hand to that done by means of machines. Since 1886 linotype machines, doing four or five times as much work as an average old style compositor, have almost entirely replaced hand composition, and on these ingenious machines, the type in most modern newspaper offices is now set. The equipment of a large newspaper office includes forty or fifty of these machines, which have keyboards similar to those of typewriters. As the operator depresses the key



LINOTYPE MACHINE ROOM, NEW YORK HERALD

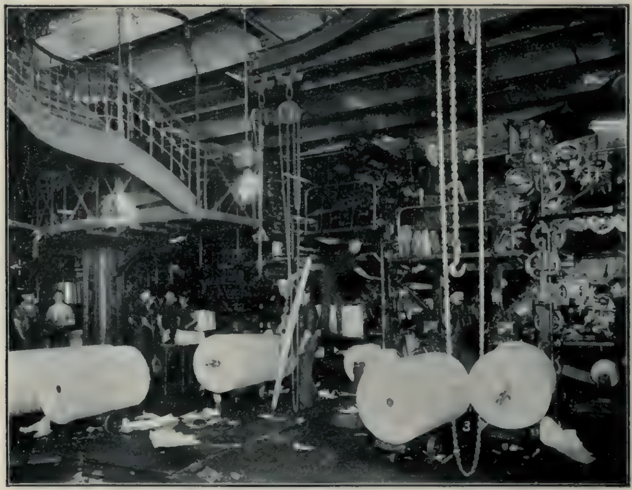
corresponding to the character he wishes to set, a matrix falls into a carrier in front of him. When the line is complete, the operator pulls a lever, sending the carrier to a mold into which metal is forced, and the character cast from the matrices into a solid line or "slug." As the lines are cast, they are carried forward on to a sort of shelf, from which they are removed to galleys.

After the galleys of type set on the linotypes are proved up and passed by the proofreader, they are made up into page form by the "make-up" man, and

MAKING UP THE PAPER IN THE BROOKLYN EAGLE COMPOSING ROOM

from these page forms paper matrices are made from which curved plates are cast. These plates are attached to the cylinders of a press, which in operation can print from 36,000 to nearly 200,000 impressions in an hour.

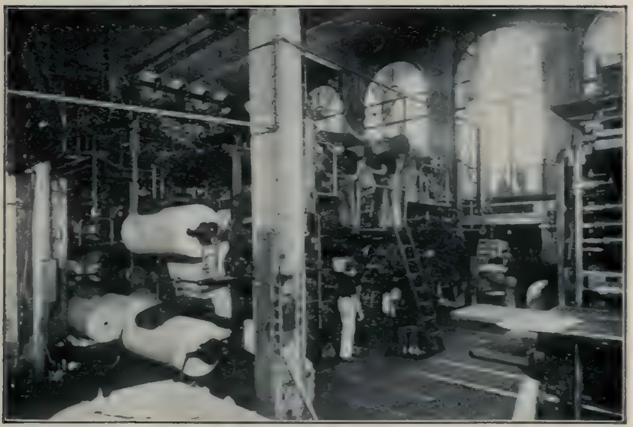
The newspaper's art department, with its corps of expert photographers, "covers" stories permitting illustrations, and by means of line and photo-engraving the photographs are converted into metal plates from which the pictures may be printed as well as the impressions from type. Every printing press of a kind that would now be installed in a representative newspaper office in New York, Boston, Philadelphia, or in any large city, costs not far from $50,000. The new style presses, the stereotype plates and the mechanical compositors have conspired in the making



VIEW OF PRESS ROOM, NEW YORK WORLD

of the modern newspaper, but all these together would have been impotent had it not been for the wonderful progress made in paper manufacture, in the adaptation of wood pulp to practical use therein, and in the introduction of other improvements in making paper for the printer's use.

As late as 1862 the paper used by newspapers generally cost twenty-four cents a pound. It was made from rag stock, for which raw material there was a constantly increasing demand. The outlook was toward even higher prices when the use of wood pulp came in, and to-day the newspapers get their blank

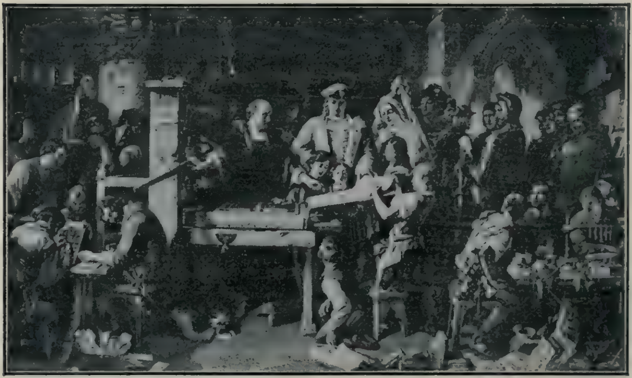


PRESS ROOM, NEW YORK HERALD

paper in rolls weighing about half a ton, the cost of which is a trifle over two cents a pound.

Newspaper work is perhaps one of the most fascinating occupations upon which a man or a woman can enter. It is full of charm, full of novelty, full of zest, but it calls for a sound mind and a sound body. The demands upon a newspaper worker are simply tremendous. No knowledge that one may get will come amiss and the variety in the profession is one of its great charms. The youth who goes into journalism ought to have what is commonly known as the "nose for news," and in writing a story it is well to keep in mind the lines that follow, which briefly set forth the requirements of all newspaper offices, *viz.*:

"When writing an article for the press,
Whether prose or poetry, just try
To express your thoughts in the fewest words
And let them be crispy and dry.
And when it is finished and you suppose
It's done exactly brown,
Just look it over and then
Boil it down!"



WILLIAM CAXTON IN WESTMINSTER ABBEY, SHOWING THE FIRST PRINTING DONE IN ENGLAND TO KING EDWARD IV AND MEMBERS OF HIS COURT

After a visit to a great newspaper office, and we have been permitted to study the paper in the making, we are in a better position to appreciate something of the feelings of Gutenberg when he took his first proof of the wonderful movable types that he had so laboriously constructed and which looked so full of charm to him, but regarding which, in his wildest dreams, he did not realize that they were destined to revolutionize the world.

A newspaper plant is a veritable fairyland through which passes thoughts, deeds, all sorts of news, and in the process it is transformed into printed matter that he who runs may read. We of to-day are so used to having the world's events served up to us over the breakfast teacups that we forget the wonder of it all in the process of newspaper making, but which lingers there in spite of everything.

Thus we see by man's intelligence our needs are supplied, and the earth made fitter for the habitation of the human race.

Our skill in weaving, our increase in knowledge, our enterprise in trade, our great works of construction, all come from the knowledge of man's weakness and needs.

In a future book, we shall tell you something of the manufacture of other necessaries of life, such as food and clothing, and all those things which make life so enjoyable.